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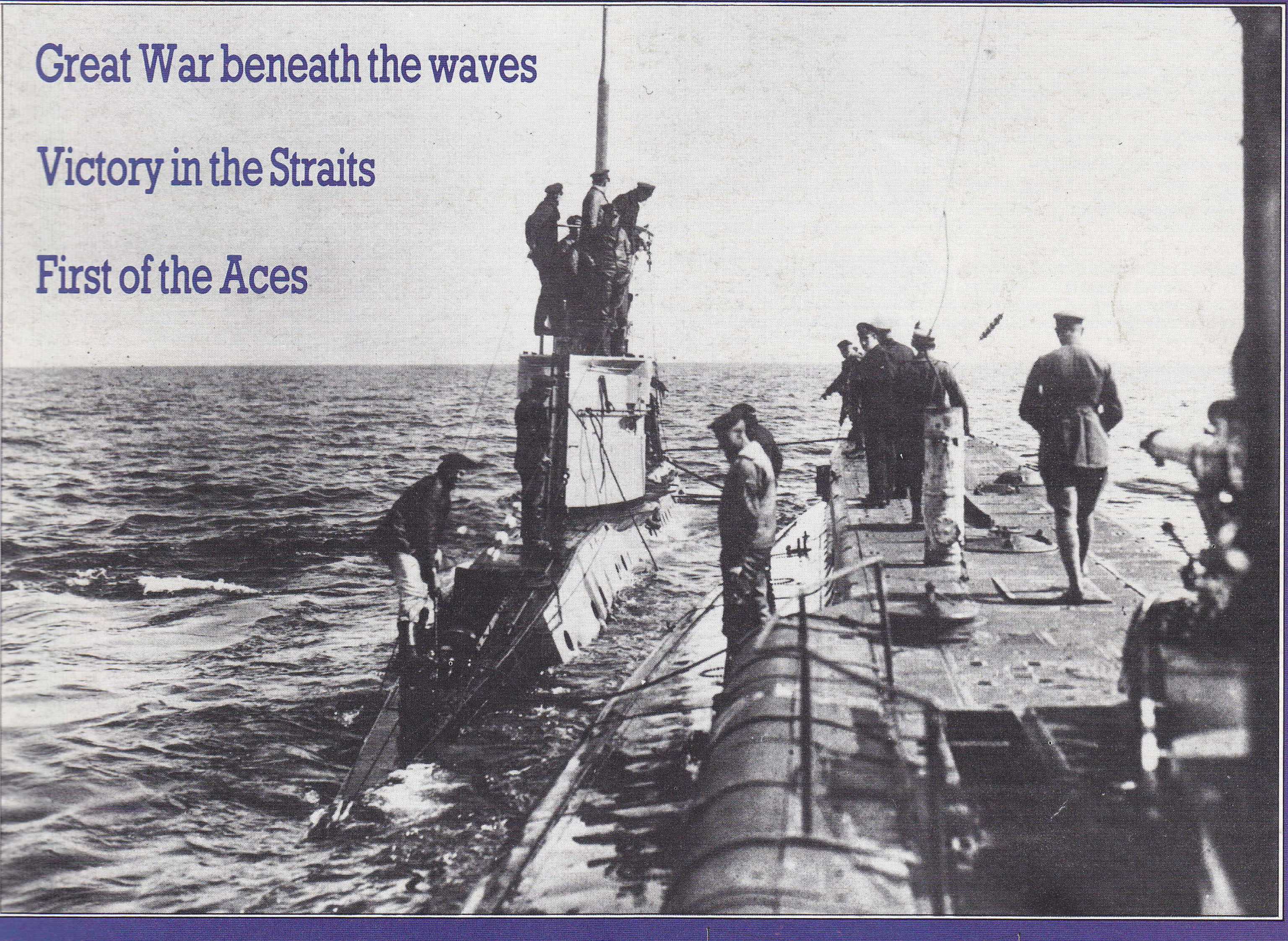

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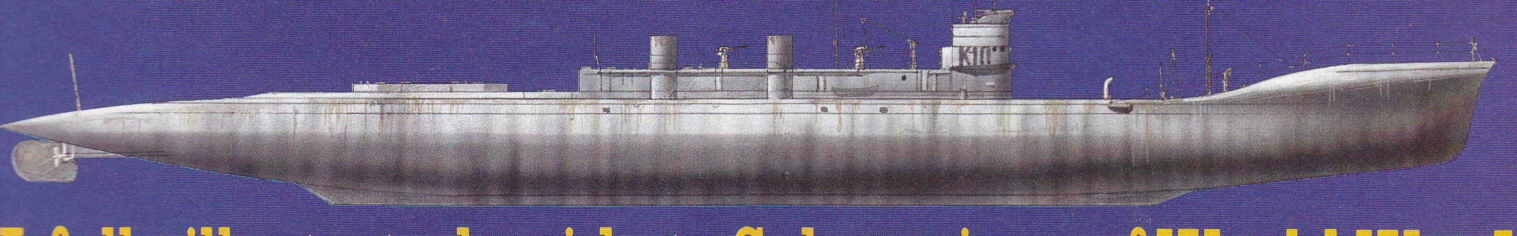

A fully illustrated guide to Submarines of World War I

WAR MACHINE

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Submarines of World War 1

From 1914 to 1918 submarines progressed from being short-range coastal craft to large ocean-going vessels capable of extended cruises. Germany soon realized their value and launched a submarine campaign against Great Britain which came close to winning the war.

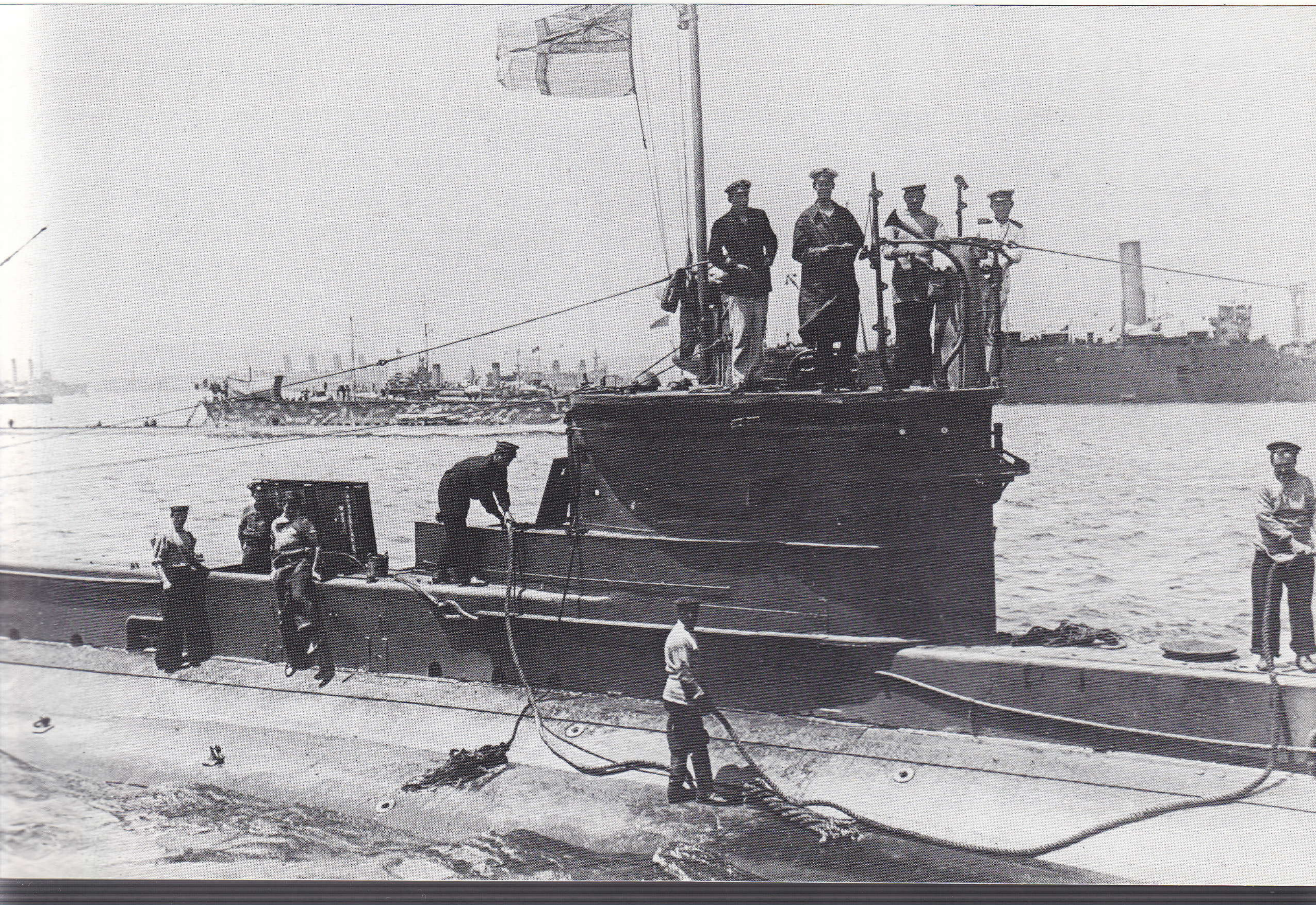
The major navies consistently attempted to design submarines with long range and high surface speed to operate in close support of the battlefleet, but experience proved this to be unworkable. J7, seen right, was built for the Royal Australian Navy in 1917.

In the course of a British naval exercise in the early years of the 20th century, a submarine informed the opposing admiral that he had just been 'sunk'. The latter replied to the effect that he 'would be damned if he was', and carried on. Such entrenched attitudes were typical, despite the fact that similar evolutions had consistently demonstrated the submarine's potential: the truth was unpalatable and was therefore best ignored. (A current parallel exists in the average warship's totally inadequate defences against a wide variety of aerial threats.)

It is fair to say that by August 1914 submariners understood their craft's potential but had failed to convince those who mattered in the conduct of the surface war. This was the more strange in the UK, where the redoubtable 'Jacky' Fisher remained in close touch with submarine development: indeed, they were contemptuously dismissed as 'Fisher's toys' by Admiral Lord Beresford, who really should have known better.

Within weeks of the outbreak of war, the British *E9* under Horton had sunk the cruiser *Hela* near Heligoland, and Weddigen's *U-9* had disposed of three 'Cressy' class cruisers before breakfast, followed shortly by HMS *Hawke*. The British *B11* penetrated the Dardanelles defences to knock out the *Messoudieh*, offset by the loss to submarine attack of the first battleship, HMS *Formidable*, off Portland. In the Adriatic, Austrian boats dealt as harshly with the French and Italians, and the long British tradition of close blockade came to a bloody finale when Hersing's *U-21* sank two more battleships off Gallipoli, having made the long passage from Germany for the occasion. In a bare nine months, the submarine had firmly stated that war at sea would never again be the same. Under the German flag it went on to the controversial war against merchant shipping. In sinking nearly eight million gross registered tons of British shipping it nearly won the war but, in the process, so outraged the neutral Americans that they finally declared for the Allied cause. Germany's war-winning weapon ultimately worked against her own interests and brought about her downfall.

Detail of one of the Royal Navy 'E' class boats off the Dardanelles with a French submarine in the background. It fell to E2 to make the last patrol there in January 1916 as the Allied evacuation was completed. The land campaign may have been a disastrous failure, but the submarine operations were a credit to the Royal Navy.



GERMANY

'UB' classes

The *UB classes* were coastal submarines which stemmed initially from a requirement for a boat of limited performance that could be transported by rail to its area of operations. Though the hull would need to be divided into three main sections to achieve this, the major restriction was on diameter. For this reason, the initial 17 boats completed in 1915 (and later designated the **'UB I' class**) were single-hulled, with diving, trimming and fuel tanks inboard. They were also single-screwed and, with the diesel in the unreliable early days of its development, this proved a mechanical drawback. Sections were round, flattening forward to an ellipse to allow two 450-mm (17.7-in) tubes to be carried side by side. As there was space for only two spare torpedoes, the lack of a proper deck gun was a real limitation, but those operating from Bruges (following assembly at Antwerp) were a nuisance off the British east coast, particularly to the fishing fleet, at that time composed mainly of sailing craft. Several operated from Pola on the Adriatic, and one of these, von Heimburg's *UB-14*, sank the troop transport *Royal Edward* near Kos in August 1915 with the loss of almost 1,000 lives. In the November he sank also the British submarine *E20*, which was keeping a compromised rendezvous.

Though the 'UB Is' met their designed aims, they inevitably proved inadequate with the war stalemated on land and, therefore, becoming of greater importance at sea. Their 1915-6 follow-ons, the **'UB II' class** boats, were therefore considerably enlarged to allow for twin-screw propulsion, together with greater power and range. As there was no longer any prospect of rail transportation, they could be given saddle-tanks, the double-hulled construction allowing some tanks to be carried outboard, thus increasing space within. This in turn permitted two 500-mm (19.7-in) tubes to be carried forward, vertically disposed, together with four reloads. A 50-mm (1.97-in) deck gun and a radio installation were also fitted in the class, which ran to 30 boats (*UB-18* to *UB-47*). Beginning in 1917, the first of 85 **UB III' class** boats (*UB-48* to *UB-132*) came into service. Compared with the 263/292 tons of the 'UB IIs', these were of 516/651 tons and large enough for unrestricted operations around the whole of the UK. With five tubes and an 88-mm (3.46-in) gun, they were comparable in size to earlier sea-going U-boats. Eight 'UB Is' became war losses, as did 21 'UB IIs' and 40 'UB IIIs'.

Specification

'UB I' class

Displacement: 127 tons surfaced and 142 tons dived

Dimensions: length 28.10 m (92 ft 2.5 in); beam 2.97 m (9 ft 9 in); draught 2.90 m (9 ft 6 in)

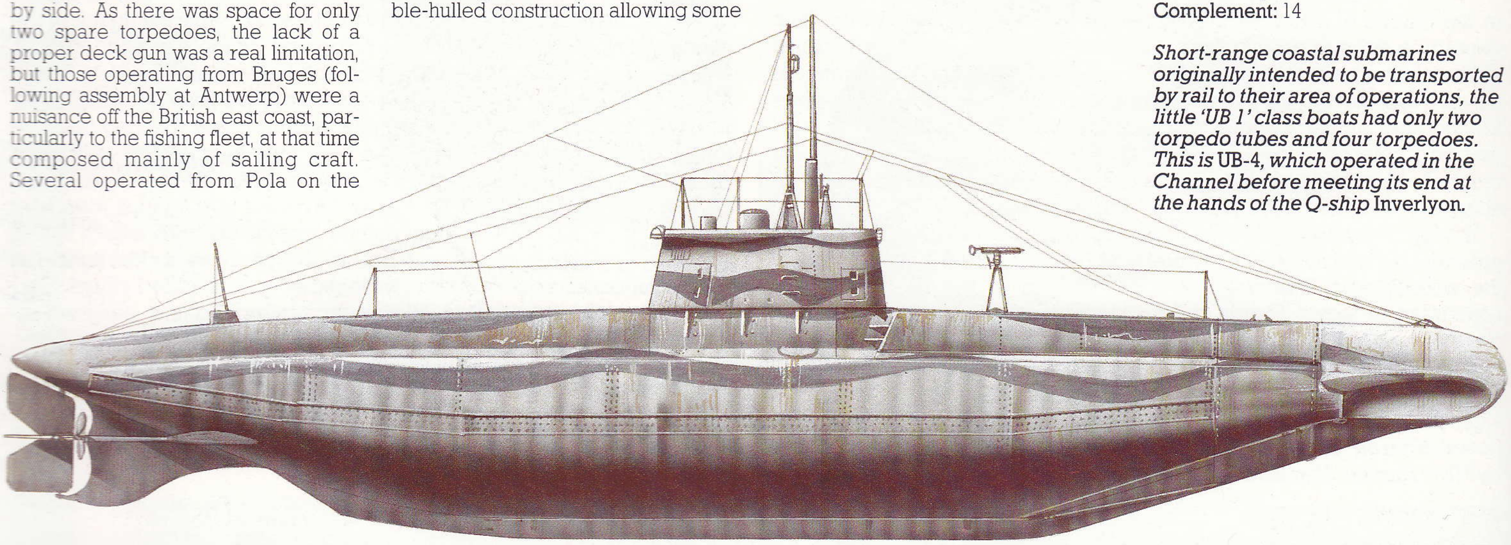
Propulsion: one diesel delivering 44.7 kW (60 bhp) and one electric motor delivering 89.5 kW (120 hp) to one shaft

Speed: 6.5 kts surfaced and 5.5 kts dived

Range: 3000 km (1,864 miles) at 5 kts surfaced, and 85 km (53 miles) at 4 kts dived

Armament: one machine-gun, and two 450-mm (17.7-in) torpedo tubes (bow) with four torpedoes

Complement: 14

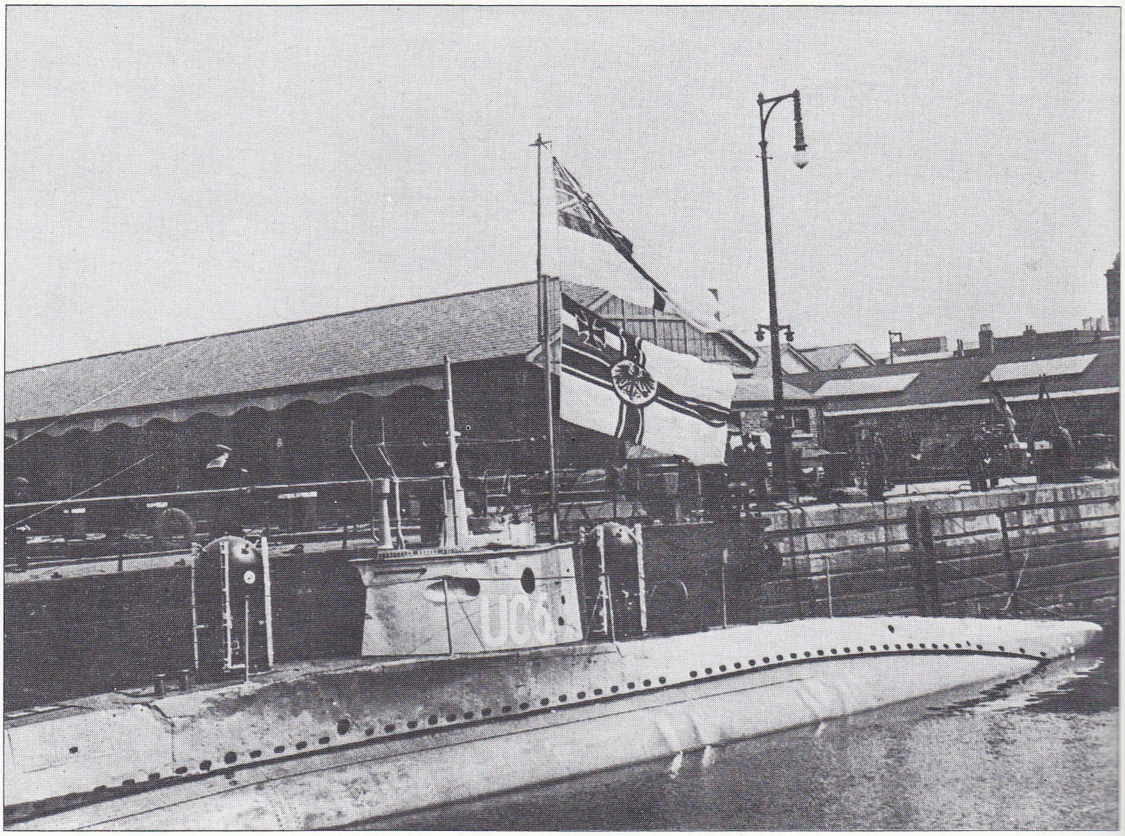


***Short-range coastal submarines originally intended to be transported by rail to their area of operations, the little 'UB 1' class boats had only two torpedo tubes and four torpedoes. This is UB-4, which operated in the Channel before meeting its end at the hands of the Q-ship* Inverlyon.**

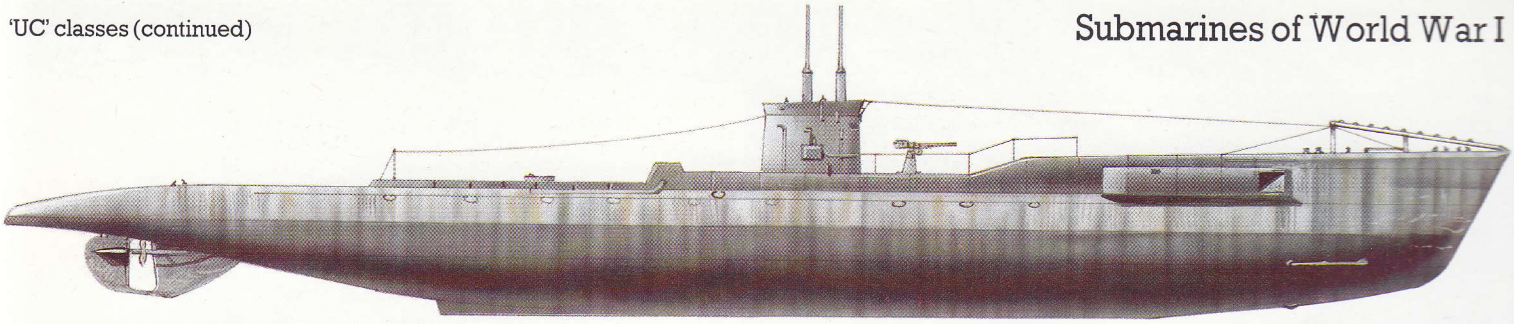
GERMANY

'UC' classes

The **UC** (later **'UC I'**) **class** was built in parallel with the 'UB I', taking its hull as a basis but stretching it for duty as a pure minelayer, no torpedo tubes being fitted. Mining the teeming coastal traffic lanes of the UK was a particularly cost-effective form of warfare but fraught with problems in the narrow and constricted channels, and a small boat was essential. Something under 6 m (19.7 ft) longer than the 'UB I', the minelayer employed a new principle in having six centreline minetubes passing right through the hull forward of the fin. From the bottom these tubes sloped aft at about 30° and were free-flooding. Each could accommodate two mines which, being negatively buoyant when attached to their sinkers, could be dropped out of the bottom of the tubes with the boat moving slowly ahead. Fifteen of the class (*UC-1* to *UC-15*) were built for assembly elsewhere during 1915, and the hazards of their trade were such that only one survived to the end of the war. Not the least problem was a boat's liability to strike her own mines, two (and possibly as many as five) of the class being so lost. A further drawback was that the depth-setting for the mines could not be altered once at sea.



UC-5 was stranded and captured by the Royal Navy; she is seen here on display at Temple Bar pier in 1916. She carried no torpedoes, just 12 mines launched via six vertical tubes which passed right through the hull.

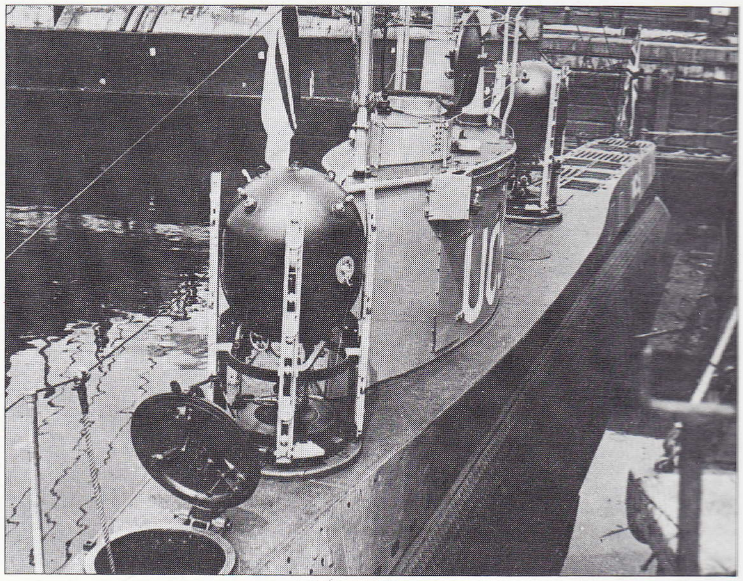


Above:* UC-74 *was one of the longest-ranged vessels of the 'UC-II' class minelayers. Bigger boats than their predecessors, the class carried six 100-cm (39.4-in) mine tubes with 18 UC200-type mines. Her sister* UC-65 *sank HMS* Ariadne *off Beachy Head in 1917, but was herself sunk by the British* C-15 *later in the year.

During 1915 foreign public opinion obliged the Germans to restrict their U-boat operations, and minelaying took on a greater significance. Further specialized boats were required and, as in the 'UBs', the size was increased. The resulting **'UC II' class** was of 49.4 m (162.1 ft) overall length, had twin screws and was of 417/493 tons displacement. Each of the six tubes could take an extra mine by virtue of a deep casing forward and a wide and substantial keel. A further improvement was to include also three 500-mm (19.7-in) torpedo tubes and an 88-mm (3.46-in) gun to permit offensive operations on the completion of the lay. Two of the tubes were external to the pressure hull, flanking the tops of the mine chutes in the forward casing; the third was inboard and right aft, cramping the rudder and hydroplane gear. Sixty-four 'UC IIs' were built (*UC-16* to *UC-79*), 43 becoming war losses, and these were followed by 25 **'UC III' class** boats (*UC-90* to *UC-114*) which improved upon the poor surface seakeeping qualities of the 'UC II' and had a 105-mm (4.13-in) gun.

Two types of ocean minelayer, the 10 boats of the 655/830-ton 'UE I' class and the 10 boats of the 1,165/1,512-ton 'UE II' class, were also available with capacities of 32 and 48 mines respectively, laid from a dry-storage chamber through two tubes aft.

Specification
'UC I' class
Displacement: 168 tons surfaced and 183 tons dived
Dimensions: length 34.00 m (111 ft 6.5 in); beam 3.20 m (10 ft 6 in); draught 3.00 m (9 ft 10 in)
Propulsion: one diesel delivering 67 kw (90 bhp) and one electric motor delivering 130.5 kW (175 hp) to one shaft
Speed: 6 kts surfaced and 5 kts dived
Range: 1400 km (870 miles) at 5 kts surfaced, and 95 km (59 miles) at 4 kts dived
Armament: 12 mines
Complement: 16



Submarine-launched mines accounted for many Allied warships, including HMS* Hampshire, *mined by* U-75 *(Lord Kitchener was among the dead); the Italian battleship* Regina Margherita *(mined by the Austro-Hungarian* UC-14*); and the French cruiser* Kléber *(mined at the entrance to Brest by* UC-61*).

GERMANY

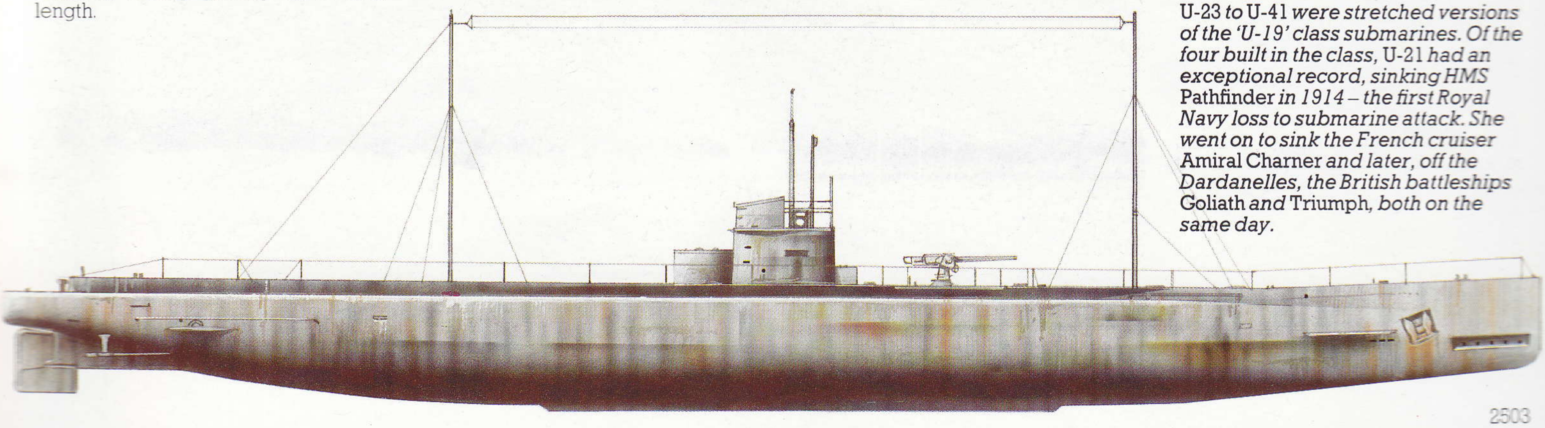
'U-19' class

The *U-19* was not a great technical advance over the 14 U-boats that preceded her, all of which were to play a war role; what she did introduce when completed in 1913 was the diesel engine. Earlier boats had been propelled on the surface usually by Köting engines which burned paraffin or heavy oil, deemed safer than the petrol engine used in earlier British boats though, interestingly, the latter had started to use diesels in the 'D' class boats some three years earlier. Though the Germans had the diesel, they were still proving its long-term reliability. Diesels, besides being safer, were far more economic, an important factor with respect to operational radius. One diesel per shaft could also develop more power than the two Körting engines previously used in tandem, saving greatly on overall length.

The design continued the tried four-tube layout, with two forward and two in the cramped after sections, but increased the calibre from 450 to 500 mm (17.7 to 19.7 in). This arrangement was to be favoured for the majority of the following war-built classes. An important innovation was the adoption of a deck gun, an 88-mm (3.46-in) weapon. The circular-section pressure hull was flanked by substantial saddle tanks with flattened top surfaces, usually awash, and the narrow centreline casing had a sheer forward to assist in better surface seakeeping. Light, folding masts were carried to spread the wireless aerials.

Only four 'U-19' class boats were built (*U-19* to *U-22*), the design then being stretched by 0.5 m (1.64 ft) to uprate the diesels by a cylinder apiece. With only minor variations, *U-23* to *U-41* followed this arrangement, accounting for sea-going U-boat deliveries until early 1915. Of the original group, *U-21* become known under her commander, Hersing, who inflicted the first loss on the Royal Navy by submarine attack when, on 5 September 1914 he sank the scout cruiser HMS *Pathfinder* in the North Sea. On 29 January 1915 he cheekily surfaced off Walney Island to bombard the Barrow works of Vickers, only to be chased off by a shore battery. Surviving the war, *U-21* 'foundered' en route to surrender.

Specification
'U-19' class
Displacement: 650 tons surfaced and 837 tons dived
Dimensions: length 64.20 m (210 ft 7.5 in); beam 6.10 m (20 ft 0 in); draught 3.60 m (11 ft 10 in)
Propulsion: two diesels delivering 1268 kW (1,700 bhp) and two electric motors delivering 895 kW (1,200 hp) to two shafts
Speed: 15.5 kts surfaced and 9.5 kts dived
Range: 13900 km (8,637 miles) at 8 kts surfaced, and 150 km (93 miles) at 5 kts dived
Armament: one 88-mm (3.46-in) gun, and four 500-mm (19.7-in) torpedo tubes (two bow and two stern) with six torpedoes
Complement: 37



U-23 *to* U-41 *were stretched versions of the 'U-19' class submarines. Of the four built in the class,* U-21 *had an exceptional record, sinking HMS* Pathfinder *in 1914 – the first Royal Navy loss to submarine attack. She went on to sink the French cruiser* Amiral Charner *and later, off the Dardanelles, the British battleships* Goliath *and* Triumph, *both on the same day.*

The Great War beneath the waves

In 1914 the submarine was regarded by many naval officers as a short-range defensive weapon manned by grubby engineer types, and not even the Germans appreciated its potential as a war-winner. In fact the development of underwater weapons revolutionized naval warfare; battleships remained the final arbiters of war at sea, but the submarine was evolving rapidly.

***U-8** was the first U-boat lost, being sunk by HMS **Maori** and HMS **Gurkha** on 4 March 1915. The ram was a favourite method of submarine destruction: **U-29** was the unluckiest in this respect, being rammed by the 18,000-ton bulk of HMS **Dreadnought** two weeks later.*

It was fortunate for the UK that pre-war German exercises had failed to highlight the great potential of the U-boat. The UK herself had already committed considerable resources to submarines, so that their possibilities were more widely appreciated. But the manner of their wartime use and an accurate definition of the threat that they posed to individual warships, to the battlefleet and, equally importantly, to merchant shipping, was far from formulated. Peacetime exercises tended to be set-piece affairs, modifying established doctrine rather than evolving new concepts, particularly any as revolutionary as using submarines in an aggressively offensive role.

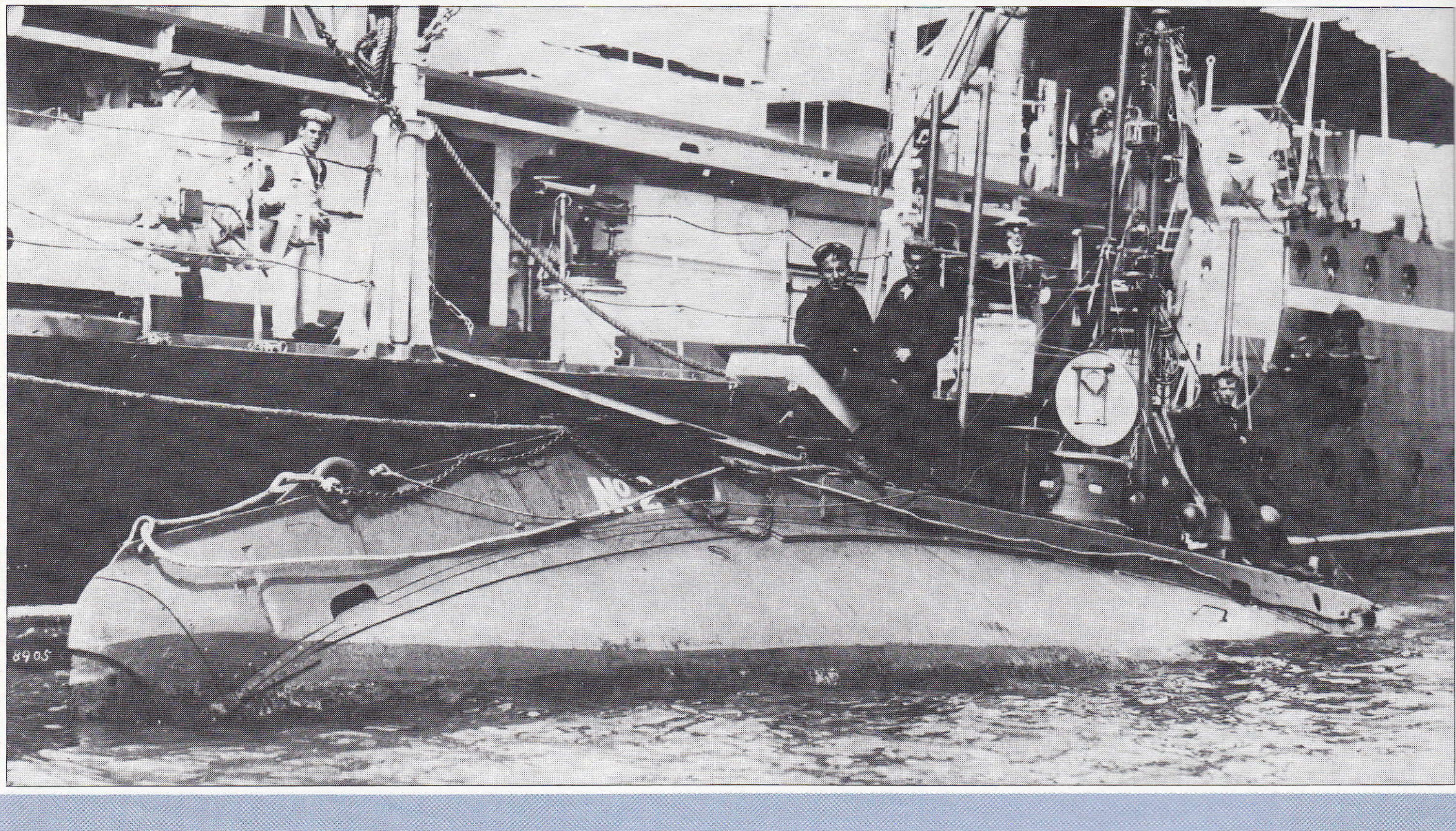
Probably the submarine's greatest drawback was in its being viewed as a piece of machinery rather than a ship, a device for engineers rather than seamen at a time when 'oily rags' were viewed as an inferior race. Submariners were of a closed order (known defensively in the Royal Navy as 'The Trade') and their craft were looked upon as near-seas defensive weapons with little relevance to fleet matters. Just as the Germans had failed to foresee their submarine arm's offensive qualities, so had the British failed to develop suitable effective means for their detection and destruction.

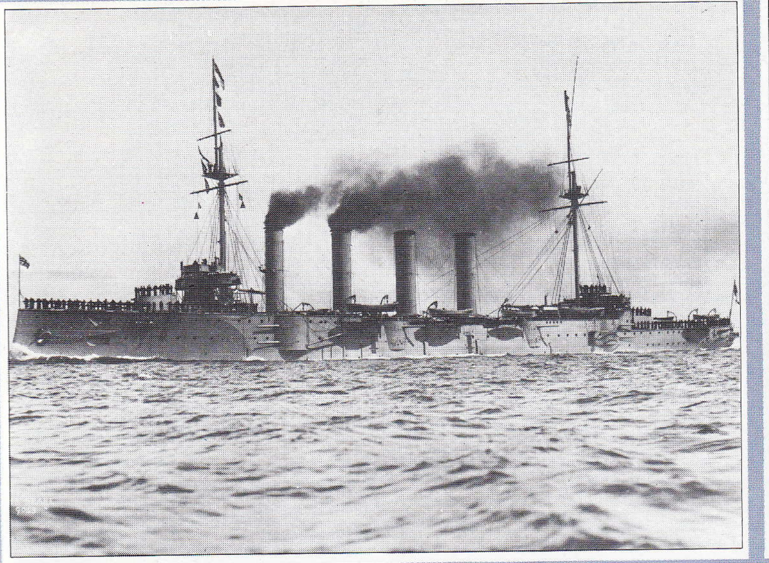
Even by 1914 the submarine itself had progressed from the single-hulled, 'spindle' type to larger saddle-tanked or double-hulled varieties that possessed far greater usable internal volume and vastly improved seakeeping. The latter point was of great importance for submarines (or 'submersibles'), with their poor submerged performance, were expected to operate for the greater part on the surface, diving for evasion or attack. Little thought had been devoted to the problems posed by extended patrols or to equipping them for use against their most likely targets. Thus, for instance, when the Germans discovered (to their own surprise as much as anybody's) that the U-boat's range and endurance was considerably greater than anticipated, an immediate limitation was imposed by the few torpedoes carried. This, with existing boats, would result in fruitful patrols being curtailed and inordinate time spent in transit if a way could not be found to resupply on station or develop other modes of attack. In practice, torpedoes were reserved for high-value or difficult targets while merchantmen, the protection of which Germany rapidly discovered to be the UK's weak point, could be sunk by gun or demolition charge. In turn, however, this robbed the U-boat of its greatest advantage, stealth, and resulted in countermeasures such as 'Q' ships. Slow submergence had been seen in peacetime as of little consequence, but proved gravely disadvantageous when the tables were suddenly turned. Improvements could often be made simply by cutting extra limber holes in the casing structure.

Torpedoes in general worked well for their time, but the lack of range and killing power of the British 457-mm (18-in) and the German 450-mm (17.7-in) weapons led to the introduction of 533-mm (21-in) and 500-mm (19.7-in) calibres. These, inevitably, demanded larger boats but could strike from a safer range. The extra size brought about the abandoning of athwartships tubes by the British and less stress on manoeuvrability for rapid disengagement.

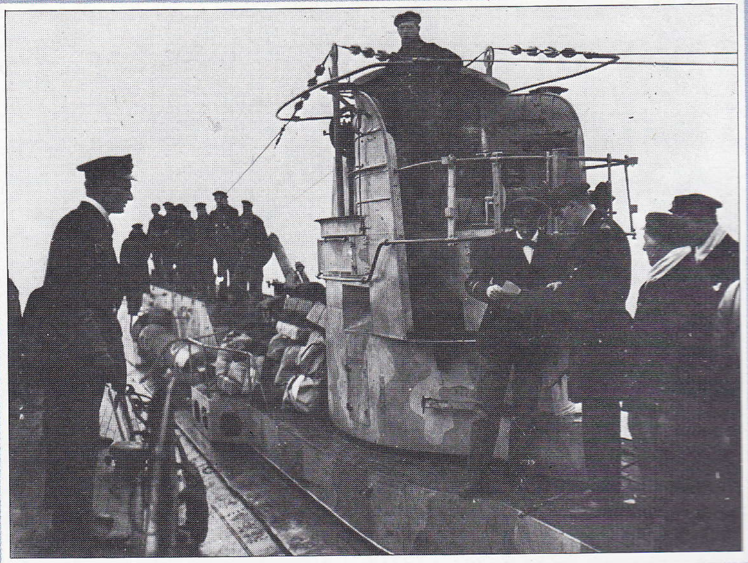
As British boats would likely be operating against warships, guns were little in evidence at the outset. Inadequate 6-pdr guns were superseded by 12-pdr weapons and later boats carried one or two 102-mm (4-in) guns as the best means of countering surfaced U-boats. As an alternative to the torpedoing of merchantmen, the Germans found the gun indispensible, its calibre jumping from 50 mm (1.97 in) progressively to 88 mm (3.46 in), 105 mm (4.13 in) and eventually 150 mm (5.9 in), with sometimes two guns fitted. Though aircraft attacks were mounted on submarines, the latter's light automatic weapons

Armed with a single torpedo tube and crewed by eight men, the 113-ton HM Submarine No. 2 was the first submarine to enter service with the Royal Navy. No. 1 foundered while on tow in 1913, only to be found again in 1981; she is being restored at the submarine museum at Gosport.





One of the victims: submarine attack accounted for the loss of 11 heavy cruisers during World War I. The 14,000-ton cruiser HMS Drake *was torpedoed and sunk by* U-79 *off Rathlin Island, Northern Ireland.* U-79 *was primarily a minelayer but had two external torpedo tubes.*



A U-boat in an interesting camouflage scheme surrenders in 1918. While most of the High Seas Fleet mutinied, one U-boat crewed by volunteer officers attempted to enter the Royal Navy anchorage at Scapa Flow on a last do-or-die mission, and became the only submarine to be destroyed by a shore station.

were not viewed specifically in an AA context. Large-calibre weapons, as fitted in 'monitor' submarines, were an aberration and contributed nothing to mainstream submarine development.

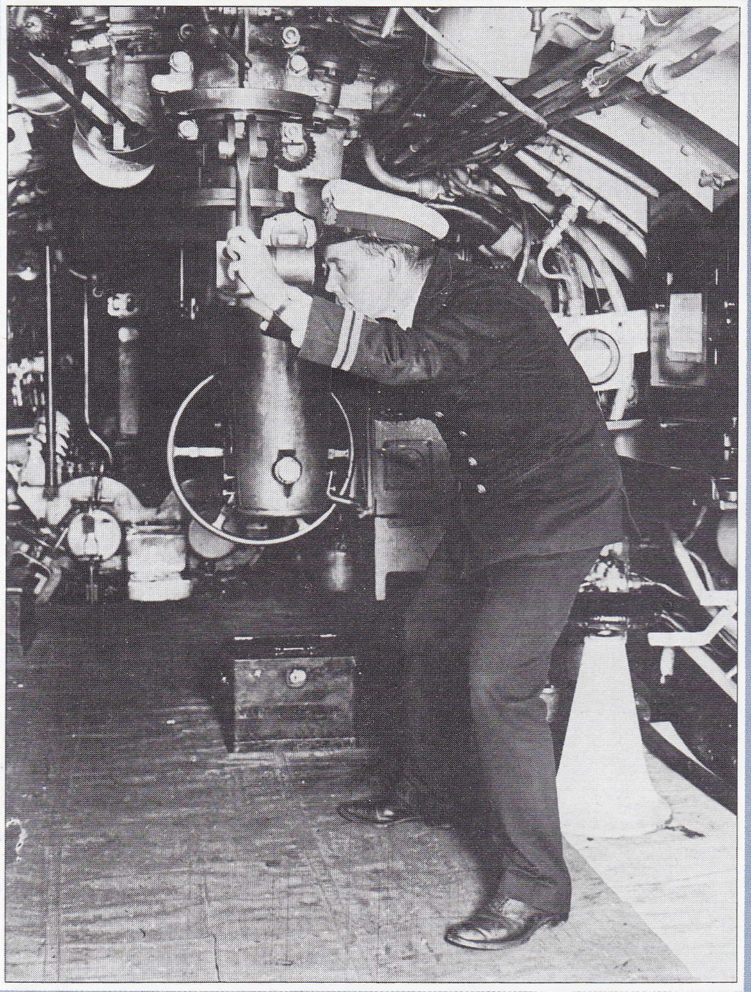
Minelaying was taken seriously by the Germans, who appreciated its cost-effectiveness far more than did the British. Where the latter converted a few standard boats, the former built many coastal and ocean boats configured for the task. Both sides used roughly the same system, with mines laid from free-flooding stowage chutes; it was hazardous and slow, however, and the British changed to mine stowage in the length of the casing and laid over the stern.

Wireless communication was, for the most part, of unpredictable range and quality, so that the sort of centralized command exercised over the U-boats of World War II was not possible in World War I. Aerials demanded that submarines were encumbered with two tall telescopic or folding masts.

Communications between a submerged boat and a surface ship were in the experimental stage in 1914 and merged with research already being conducted into the detection of submarines by passive acoustic means. Directional hyroplanes were widely deployed, particularly by the British, both from shore station and surface ship, but contributed little of note. Perhaps surprisingly, in these days of 'towed arrays', hydrophones were being towed astern of ships in 'fish' and multi-unit arrays as early as 1917, but the big breakthrough, active detection by Asdic (later Sonar), achieved operational status just too late to be of use. At this time, nearly all submarines were very cluttered externally, had inefficient propellers and were extremely noisy, but detection still tended to occur only after they had broken cover to attack, leaving them firmly with the initiative.

Ramming and gunfire were both used against surfaced submarines but, as these could usually submerge quickly enough to avoid damage, the depth charge rapidly came into its own. Initially, British production was slow, with an average of only 200 being expended each month in 1917, but by the war's end

A U-boat makes a dramatic addition to a Sussex beach in 1919. After their victory the Allies divided the surviving German fleet amongst themselves, but many U-boats 'accidentally' foundered when German sailors were supposed to be delivering them to their new owners.

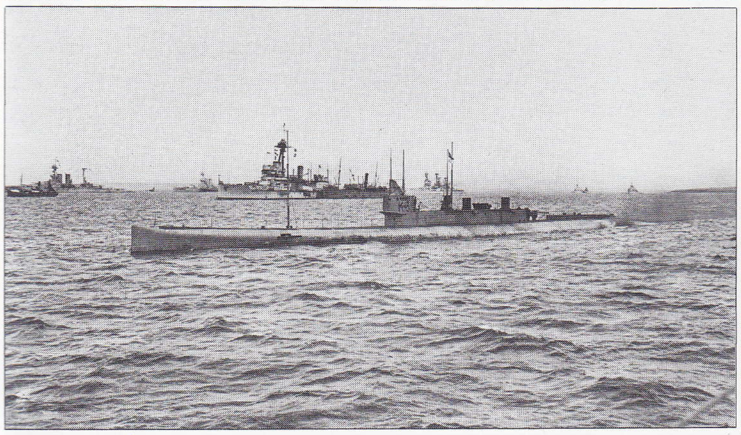


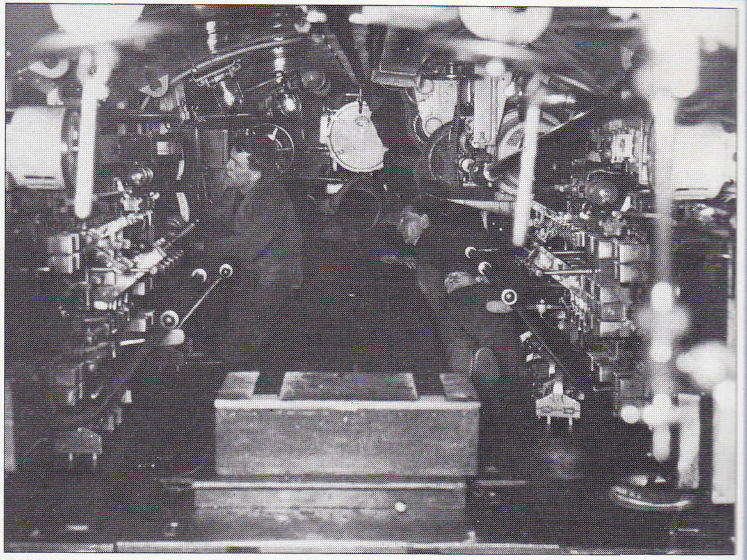
Periscope depth aboard a Royal Navy submarine. Once at sea, World War I submarine commanders were very much left to their own devices, since the radio technology which allowed the Germans to control their U-boats from ashore during World War II was only in its infancy.

this number had increased tenfold. In the end the U-boat was not so much defeated by hardware as frustrated by tactics, for the tardy introduction of convoy reduced the horrifying 5.75 million gross registered ton mercantile loss of 1917 to a manageable 2.65 million for the first 10 months of 1918.

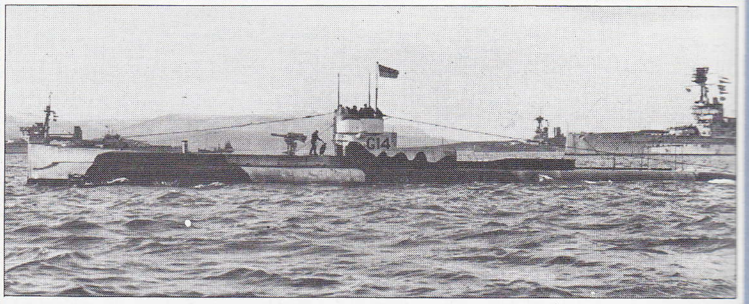
Early German research to produce a reliable diesel engine benefitted their boats with excellent machinery, only a few of the very earliest having the smoky Körting engine that burned high flashpoint fuel. Only with the 'D' class had the British switched from the more hazardous petrol engine though, in its defence, it could be pointed out that it was more compact and had a significantly better power-to-weight ratio. Diesels were started, and often reversed, by using the main propulsion motors. Storage battery technology of the time permitted submerged ranges typically less than 185 km (100 miles).

All types of submarine grew considerably in size during the war. They were less agile as a result and easier to detect, but both endurance and habitability were greatly improved so that patrols of six and seven weeks were possible.





Seamen rest in the cramped interior of a British submarine. As the boats became larger so did their crews, and space was always at a premium. It became noticed that submarines invariably smelt of stale cabbage, which has remained a disagreeable feature of submariners' lives ever since.



Seen here at Scapa Flow among the pride of the Grand Fleet, G14 was one of a 14-strong class of submarines ordered before the war in response to exaggerated rumours of the performance of German submarines. Royal Navy submariners acquitted themselves very well in World War I.

Left: The 'K' class was designed as fleet submarines capable of 24 kts surfaced. No contemporary diesels were equal to the task so steam turbines were fitted together with a diesel to drive the generator. Over a third of the hull was devoted to machinery.

Above: The short-range coastal C-class boats were the first class to be built in large numbers for the Royal Navy. Despite their short range and petrol engines, they saw extensive war service.

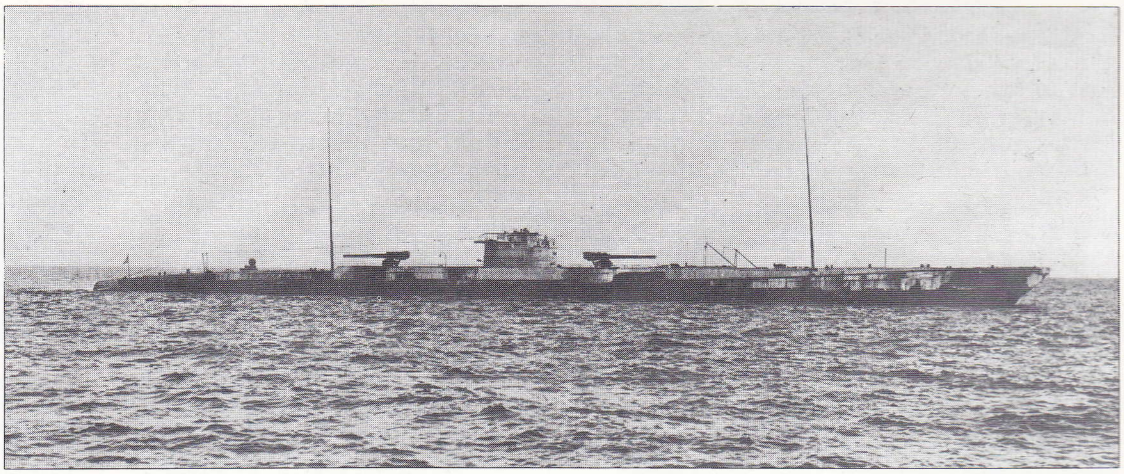
GERMANY

'U-139' class (Type UA or U-Kreuzer)

Resumption of unrestricted submarine warfare by the Germans in February 1917 went far toward obliging the USA to declare war in April 1917. Failing to anticipate this result, the Germans were caught short of boats suitable to carry the mercantile war to the American eastern seaboard, and the rearming of the slow and vulnerable *Handels U-Boote* emphasized this predicament. The construction of these large boats had, however, yielded useful experience and enabled a programme of large cruising submarines to be undertaken with confidence. Already being built at the US declaration were the big ocean minelayers and a pair of cruiser classes, the larger by far of which were the **'U-139' class** boats. Despite their size, these cruiser submarines could still carry only 13 spare torpedoes, so much debate was given to surface armament for the purpose of despatching 'soft' targets. Eventually they were given two 150-mm (5.9-in) guns and were fitted for, but not necessarily with, a further 88-mm (3.46-in) piece abaft the fin. A low bulwark around the amidships section was designed to keep down the amount of free water that would otherwise have swilled about to hamper gunlaying, and a retractable 4-m (13.1-ft) rangefinder was housed in the after end of the superstructure. A respectable surface speed was as important as long endurance, but diesels of high enough power were only in the development stage. Steam propulsion was considered but wisely rejected, and a speed of 16 kts had to be accepted, though even this was not achieved in practice.

It was then too late to build such submarines in any numbers, because of shortages of skilled labour and materials, and of conflicts of priorities, and the three boats were not commissioned until 1918. A planned follow-on 'U-142' class was even larger at 2,160/2,785 tons (dwarfing anything used in World War II), adding a second 88-mm gun, 18 reload torpedoes and a 40750-km (25,320-mile) cruising range. Only the lead ship of a planned nine was ever completed. Also planned, but never built, was an even larger 110-m (360.9-ft) boat with an armament of four 150-mm and two 88-mm guns, with topsides armoured for surface combat.

Only a handful of corsairs ever reached the Western Atlantic operationally. Their success was limited but their nuisance value was considerable, particularly in obliging the Americans to adopt a convoy system, with its attendant delays.



The shape of things to come: a 'U-139' type long-range cruiser submarine, which displaced over 2,000 tons. The powerful gun armament of two 150-mm (5.9-in) weapons was important, as despite their size they could only accommodate 19 torpedoes.

Specification

'U-139' class
Displacement: 1,930 tons surfaced and 2,483 tons dived
Dimensions: length 92.00 m (301 ft 10 in); beam 9.10 m (29 ft 10.25 in); draught 5.30 m (17 ft 5 in)
Propulsion: two diesel-electric drives delivering 2946 kW (3,950 bhp) and two electric motors delivering 1268 kW (1,700 hp) to two shafts
Speed: 15.5 kts surfaced and 7.5 kts dived
Range: 23150 km (14,385 miles) at 8 kts surfaced, and 92.5 km (57.5 miles) at 5 kts dived
Armament: two single 150-mm (5.9-in) guns, and six 500-mm (19.7-in) torpedo tubes (four bow and two stern) with 19 torpedoes
Complement: 70

GERMANY

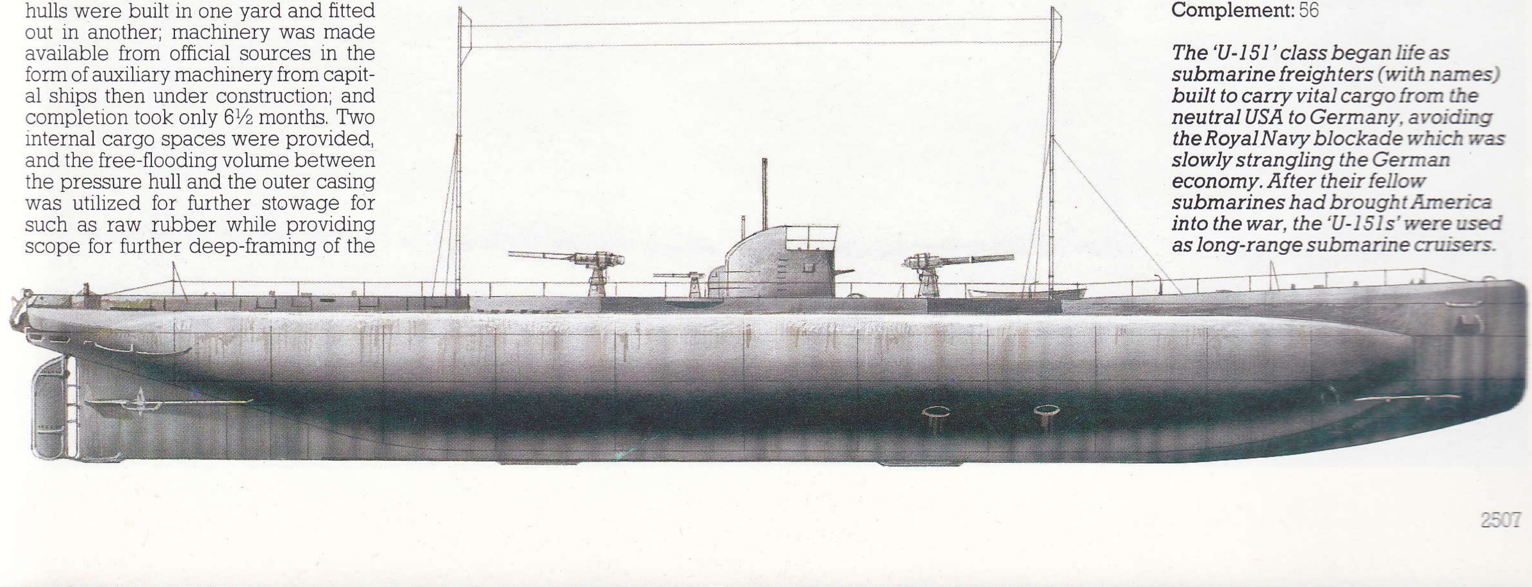
'U-151' class (Handels U-Boote)

Germany, blockading the UK with her U-boats was, in turn, blockaded by the Royal Navy. Only a short war had been planned by the Germans so, even by 1915, shortages were appearing in vital commodities, notably nickel and rubber, both of which were freely available in the still-neutral USA. Official plans to bring across small quantities in existing submarines were replaced by a commercial proposal to build specialized, unarmed, cargo-carrying U-boats (**Handels U-Boote**). Investment was underwritten by the state and an operating company, the Deutsche-Ozean Red. GmbH was established. A degree of urgency attended the construction of the first two boats, the largest yet ordered: hulls were built in one yard and fitted out in another; machinery was made available from official sources in the form of auxiliary machinery from capital ships then under construction; and completion took only 6½ months. Two internal cargo spaces were provided, and the free-flooding volume between the pressure hull and the outer casing was utilized for further stowage for such as raw rubber while providing scope for further deep-framing of the large-diameter hull. About 350 tonnes could be carried in total. Access to the inner cargo spaces was understandably poor but, for such a venture, timely arrival took precendence over speed of handling. Surfaced, the hull had a high freeboard, double-ended appearance, the stern particularly having a quite mercantile form with a deep skeg supporting a simplex-type rudder separating the twin screws, which were fully bossed. The first boat, *Deutschland*, made two successful trips to the USA with great attendant propaganda value but the second, *Bremen*, disappeared on her maiden voyage. Nevertheless, six more boats were ordered. By then (1916-7) they had to share priorities with other projects and were delivered late. This, together with the USA's entry into the war and possibly with doubts regarding the structural strength following the loss of the *Bremen*, resulted in a change of role. The **'U-151' class** boats were armed with two 150-mm (5.9-in) guns and two torpedo tubes and used as long-range cruisers. *Deutschland* became the *U-155* and alone took six tubes. These big boats had a two-month endurance and operated largely in the central Atlantic where, though their tally was small, they caused the British much anxiety because of the difficulty in providing countermeasures in so remote a region.

Specification

'U-151' class
Displacement: 1,512 tons surfaced and 1,875 tons dived
Dimensions: length 65.00 m (213 ft 3 in); beam 8.90 m (29 ft 2.5 in); draught 5.30 m (17 ft 5 in)
Propulsion: two diesels delivering 597 kW (800 bhp) and two electric motors delivering 597 kW (800 hp) to two shafts
Speed: 12.5 kts surface and 5 kt dived
Range: 38900 km (24,171 miles) at 6 kts surfaced, and 120 km (75 miles) at 3 kts dived
Armament: two single 150-mm (5.9-in) guns, two single 88-mm (3.46-in) guns, and two 500-mm (19.7-in) torpedo tubes (bow) with 18 torpedoes
Complement: 56

The 'U-151' class began life as submarine freighters (with names) built to carry vital cargo from the neutral USA to Germany, avoiding the Royal Navy blockade which was slowly strangling the German economy. After their fellow submarines had brought America into the war, the 'U-151s' were used as long-range submarine cruisers.



First of the Aces

U-35 remains to this day the most successful submarine of all time. She sank 224 ships, totalling 535,900 tons, most of them while under the command of Lothar von Arnauld de la Perière; by comparison, the most successful submarine of World War II (the German U-48*) sank 52 ships totalling 310,000 tons. After two years in the Mediterranean her commander returned to Germany and took over one of the latest U-boats, but the war ended before he could substantially improve his score.*

On 12 November 1915, the German submarine *U-35* returned to its forward base in the then Austro-Hungarian port of Cattaro. Her commander, Kophamel, in a month ranging the eastern Mediterranean, had sunk about 49,000 gross tons of shipping. He was now appointed to command the new refitting base at Pola, being relieved by an unknown with an unlikely background.

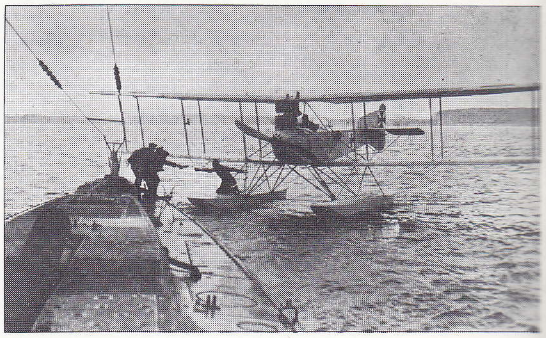
Lothar Eugen George von Arnauld de la Perière, not yet quite 30 years of age, had French aristocratic antecedents traceable to the early 15th century. His father was a State Auditor in Potsdam but a great grandfather had earned a Pour le Mérite with Oakleaves while serving as a *Generalleutnant* under Frederick the Great in 1757.

The 10-year-old Lothar was placed as a naval cadet at Wahlstatt, joining the Kaiserliche Marine seven years later. Specializing in torpedoes, he served in the cruiser *Emden* in the Far East in 1911-3 before being drafted to the staff of Admiral von Pohl, soon to be C-in-C of the High Seas Fleet. His next move was to the *U-35*.

Ominously, Kophamel had reported the Mediterranean eastern basin to be a good hunting ground, with 'few patrols' and 'shipping (following) prescribed courses'. After a short refit, U-35 sailed on 20 February 1916 to operate between Malta and Crete. His first kill, on 26 February, was the French auxiliary *Provence II*, over half the 1,800 troops aboard perishing. Her status allowed a submerged attack with no warning but, in order to conserve torpedoes, von Arnauld had wisely conscripted a good gunner from the fleet. While, in the next two days, two ships were sunk by gunfire, a third escaped because the boat's movement made shooting difficult. On 29 February four torpedoes were expended in sinking the British sloop HMS *Primula*. The first took her bows off, but the little ship went full astern, not only evading two further shots but also attempting to ram the submarine. Respecting her two 102-mm (4-in) guns, the German drew off and sank her with his last torpedo, which obliged him to return to Cattaro after a patrol of only one week.

Returning immediately, von Arnauld found the area almost devoid of shipping, a month's patrol yielding only one respectable prize, the 13,540-ton British transport *Minneapolis*, which took two days to founder.

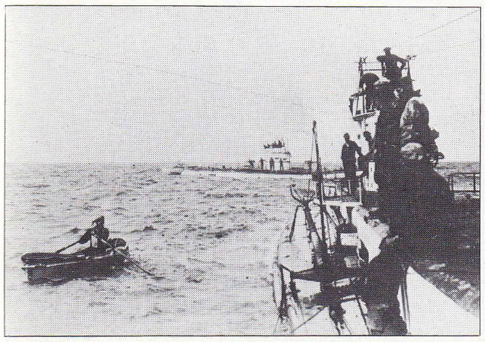
Following rectification of machinery defects, *U-35* appeared in the western Mediterranean in June 1916. Between 10 and 24 June he sank 40 ships, mostly small French and Italian traders, but aggregating 57,000 grt. With so many targets available, it was noteworthy that when the British ship *Clodmoor* made a spirited defence, she survived. On 21 June von Arnauld entered Cartagena to deliver a letter from the Kaiser to King Alfonso of Spain and finally returned only when 520 rounds of ammunition had been expended.



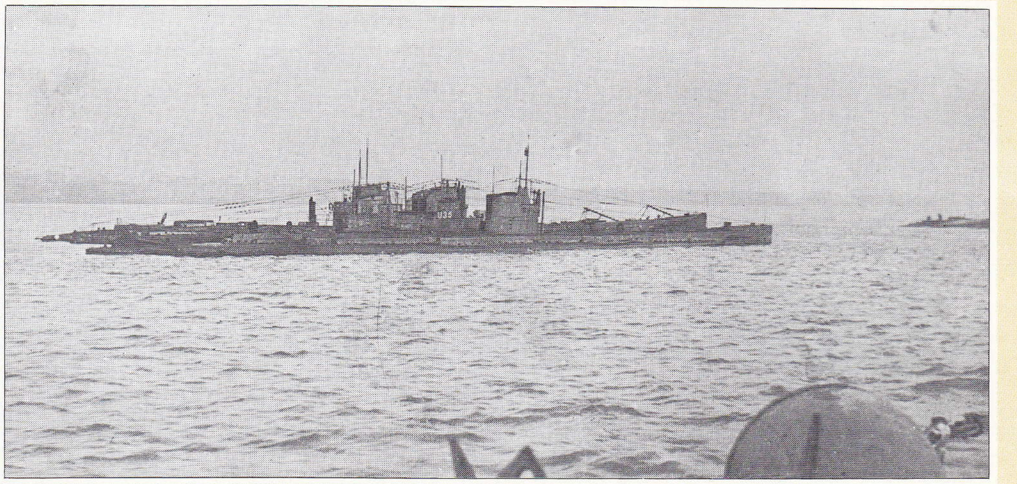
U-35 *receives dispatches from a Friederikshafen seaplane in the Mediterranean. The Kaiser once used* U-35 *to deliver a personal message to the King of Spain. On his way to and from Cartegena, Von Arnauld expended over 500 rounds of ammunition against Allied merchantmen.*

On 26 July he sailed again for the same area on what was to be the war's most productive U-boat patrol. In 25 days he destroyed 54 ships totalling about 90,000 grt, all of which were attacked with the *U-35* surfaced. Von Arnauld took considerable risks to abide by the rules. On 14 August, for instance, in sinking no less than 11 small Italian traders rounding northern Corsica, he was jumped by the same number of French anti-submarine ships. Next day, having stopped a small vessel, he was approached by another, large and unmarked, which suddenly opened a heavy fire at '60 hectametres' (about

U-35 *lies on the surface observing four warships steaming over the horizon in April 1917; von Arnauld had the mortifying experience of missing the large French cruiser* Waldeck Rousseau *the previous year. Most of* U-35*'s kills were achieved by surface action, which was not forgotten by the veterans joining the inter-war Kriegsmarine.*



U-35 *makes a rendezvous with a later-model U-boat. Lack of radio equipment meant that 'Wolfpack tactics' were not yet possible, but on the other hand surface vessels had few weapons or sensors and the Allied navies took a long time to mount a serious ASW effort.*



Von Arnauld de la Perière ended the war in command of U-139*, one of the large ocean-going cruiser submarines which could range right across the Atlantic. Here his former command* U-35 *lies amongst other surrendered boats at Harwich in 1918.*

6,500 yards). Von Arnauld submerged rapidly but the ship, the Italian decoy *Città di Sassari*, pulled away. On his return he had expended over 900 rounds of 105-mm (4.13-in) ammunition but only four torpedoes, one of which had missed the French armoured cruiser *Waldeck-Rousseau*.

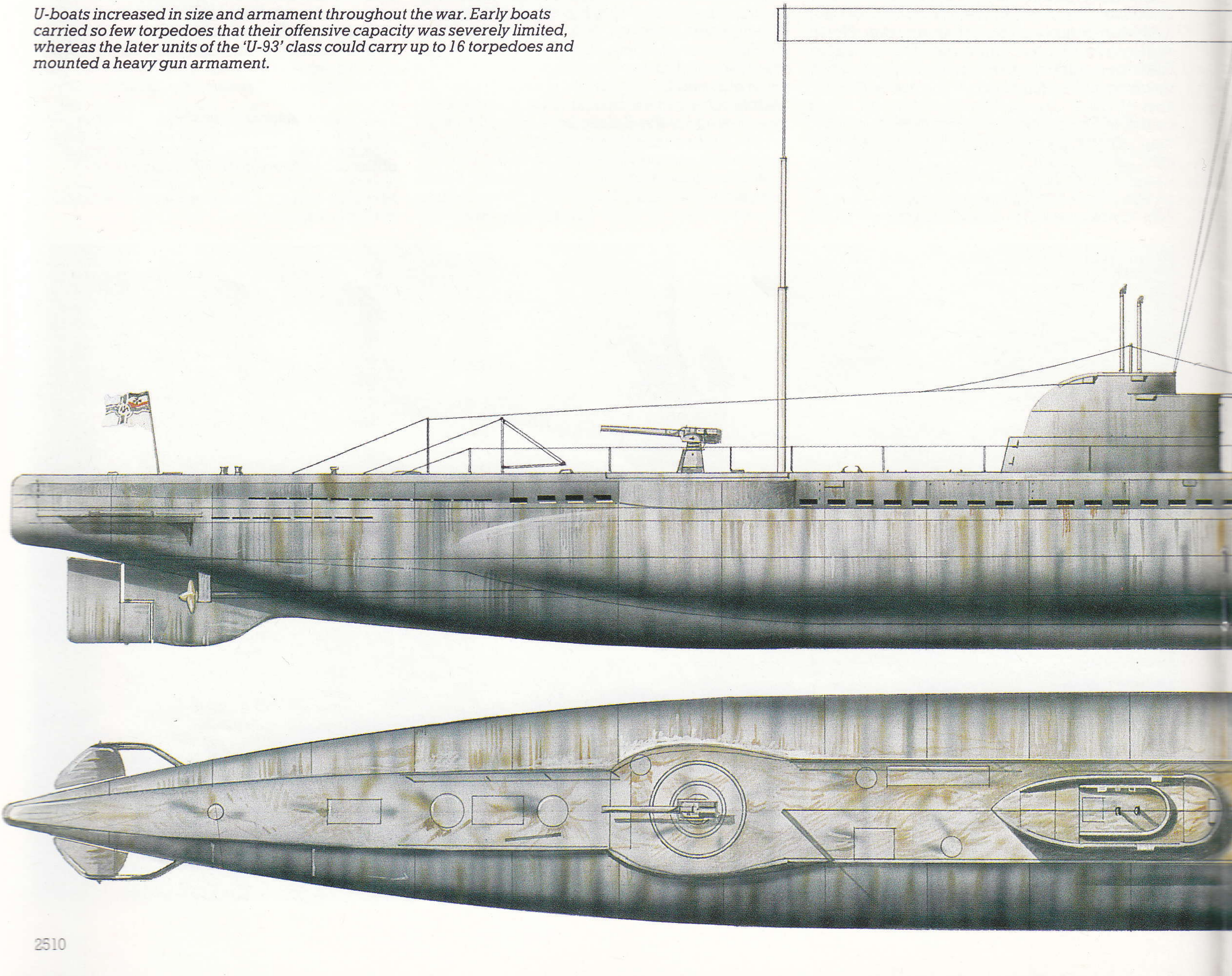
His next patrol netted 22 ships of over 70,000 grt. Typical of the larger victims was the 3,840-ton *Benpark*, on passage from North America to Genoa, with a manifest including 5,000 tons of piece goods, manufactured steel, machine tools, 900 bars of copper and 1,000 tons of coke. During this operation he again called at Cartagena to pick up a party of German officers engaged on an undisclosed mission; among them, interestingly, was a 'Lt Cdr Canaris', later head of German military intelligence. Von Arnauld was awarded the Pour le Mérite and, patrol by patrol, steadily added to his total. With the convoy system becoming organized, however, lack of targets gradually forced him to operate outside Gibraltar.

Early in 1918, with 195 ships totalling over 500,000 grt to his credit, von Arnauld returned to Germany to take command of the big U-Kreuzer *U-139* to spearhead the assault on American waters. Though others, including Kophmel's *U-140*, arrived in the summer, von Arnauld was recalled and, operating subsequently west of Spain, had little luck against well escorted convoys, and the new experience of being heavily depth-charged. Though he had received the honour of being personally received by the Kaiser, he returned to Kiel on 14 October 1918 to find the fleet in a state of revolt, and shared in its joint shame.

With no submarines in the postwar fleet, von Arnauld found himself until 1925 commanding the equivalent of naval brigades in Stralsund and Stettin. There followed a year as navigating officer in the old battleship *Elsass* before being appointed to the Naval Staff in Wilhelmshaven. In 1931, as a *Korvettenkapitän*, he joined the new submarine command; still only 45 years of age, his experience was grafted onto the rootstock of a new generation of submarine heroes.

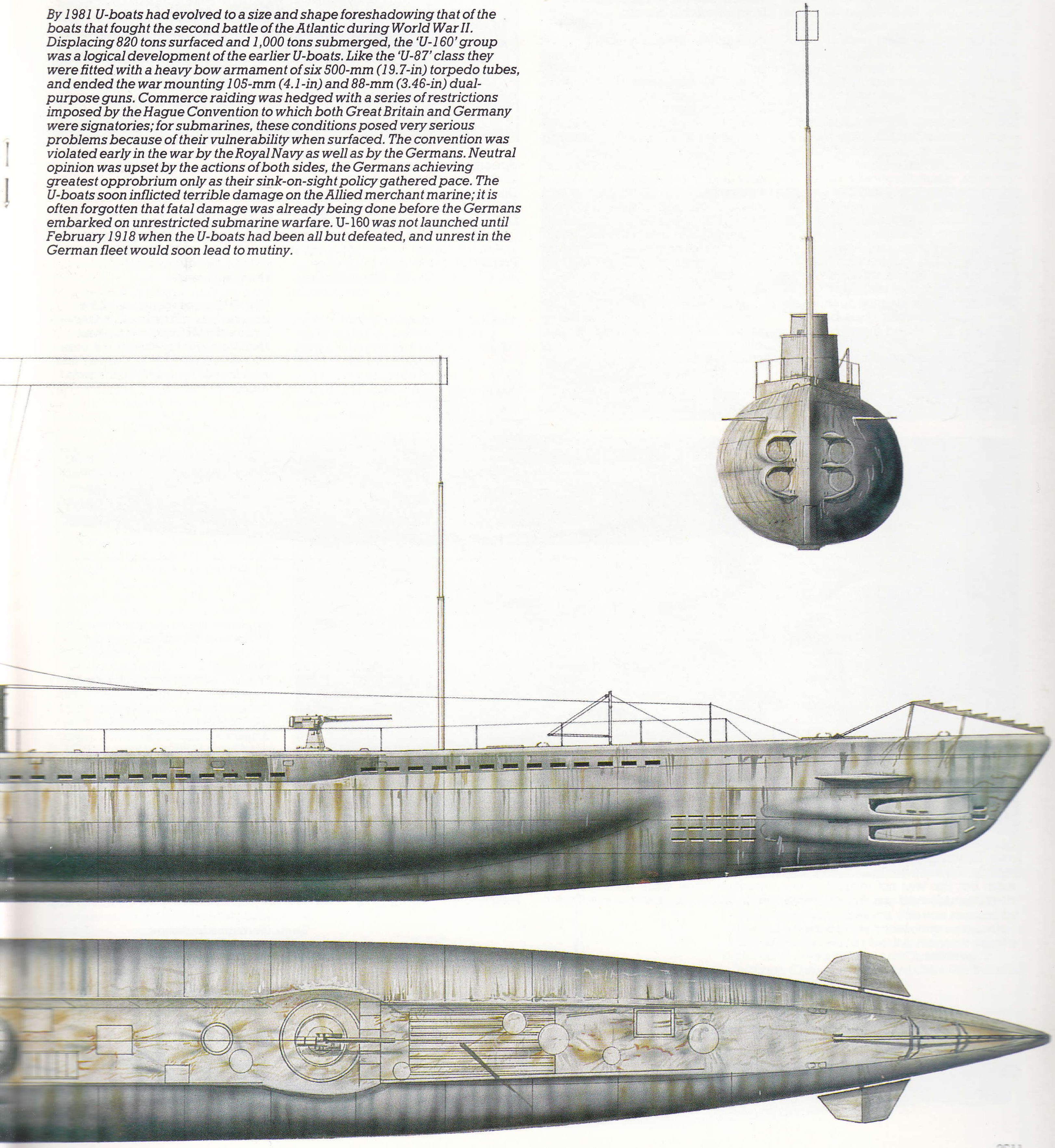
U-35 *receives visitors in the shape of the crew of a small 'UB' class submarine during a cruise in the Mediterranean. The small size of the UB boat is obvious. The figure in British uniform on* U-35 *forward of the 88-mm gun is Captain Wilson, King's Messenger, taken prisoner by von Arnauld earlier in the patrol.*

U-boats increased in size and armament throughout the war. Early boats carried so few torpedoes that their offensive capacity was severely limited, whereas the later units of the 'U-93' class could carry up to 16 torpedoes and mounted a heavy gun armament.



Unterseeboot U-160

By 1981 U-boats had evolved to a size and shape foreshadowing that of the boats that fought the second battle of the Atlantic during World War II. Displacing 820 tons surfaced and 1,000 tons submerged, the 'U-160' group was a logical development of the earlier U-boats. Like the 'U-87' class they were fitted with a heavy bow armament of six 500-mm (19.7-in) torpedo tubes, and ended the war mounting 105-mm (4.1-in) and 88-mm (3.46-in) dual-purpose guns. Commerce raiding was hedged with a series of restrictions imposed by the Hague Convention to which both Great Britain and Germany were signatories; for submarines, these conditions posed very serious problems because of their vulnerability when surfaced. The convention was violated early in the war by the Royal Navy as well as by the Germans. Neutral opinion was upset by the actions of both sides, the Germans achieving greatest opprobrium only as their sink-on-sight policy gathered pace. The U-boats soon inflicted terrible damage on the Allied merchant marine; it is often forgotten that fatal damage was already being done before the Germans embarked on unrestricted submarine warfare. U-160 *was not launched until February 1918 when the U-boats had been all but defeated, and unrest in the German fleet would soon lead to mutiny.*



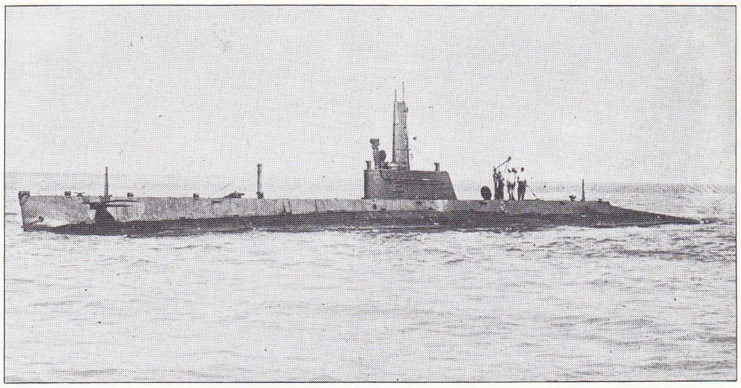
USA

American submarines

Pre-war emphasis in US submarine design had been based largely on the needs of coastal defence, with submerged handiness and rapid diving important considerations. This rather insular approach was rudely shaken from 1914 when German U-boats demonstrated their capabilities in ocean warfare. Until 1913, almost all boats had been of Holland design, excepting only the three **'G' class** boats of 1911-3 (built to the design of Simon Lake but held by the navy to be too complex) and a single Laurenti type, the **G-4** of 1912 (found to be unstable in practice, a problem discovered also by the British in their boats built to Laurenti design). The navy had little confidence in submarines in general but, being obviously so far behind European practice, characteristically began to build, though increasing the size of successive classes with great caution.

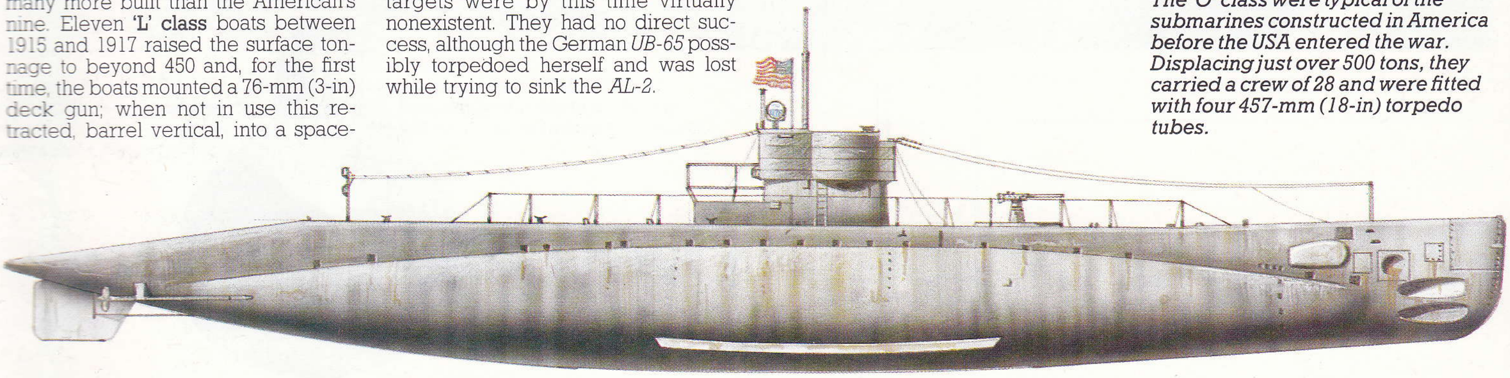
All American submarines after 1910 had diesels for surface propulsion; those built pre-war were typically of 300 tons or less but the excellent **'H' class** of about 360 tons was available in 1913, the British Admiralty having many more built than the American's nine. Eleven **'L' class** boats between 1915 and 1917 raised the surface tonnage to beyond 450 and, for the first time, the boats mounted a 76-mm (3-in) deck gun; when not in use this retracted, barrel vertical, into a space-consuming stowage in the pressure hull. The 'L' class boats were followed by an assortment of largely similar **'N'**, **'O'** and **'R' class** boats, all of the same armament and constructed at Holland's successor, the Electric Boat Company. They were rated for operations down to 61-m (200-ft) submergence.

At the USA's entry into the war her navy had a respectable 50 boats in service, but many of these were obsolete and little was to be achieved by them. In October 1917 a flotilla of 'L' class boats was sent to the Azores and a further flotilla (labelled 'ALs' to void confusion with the British 'L' class) operated in western Irish waters against U-boats, for German surface targets were by this time virtually nonexistent. They had no direct success, although the German *UB-65* possibly torpedoed herself and was lost while trying to sink the *AL-2*.



The US Navy developed its submarine arm at a leisurely pace, and at the end of the war was surprised at the superiority of the U-boats it inspected; close examination of U-111 revealed a dry bridge and a sound propulsion system. Many US vessels, like the 'K' class, suffered from unreliable diesels.

Specification
'L' class
Displacement: 456 tons surfaced and 524 tons dived
Dimensions: length 50.29 m (165 ft 0 in); beam 4.50 m (14 ft 9 in); draught 4.04 m (13 ft 3 in)
Propulsion: two diesels delivering 895 kW (1,200 bhp) and two electric motors delivering 597 kW (800 hp) to two shafts
Speed: 14 kts surfaced and 10 kts dived
Range: not known
Armament: one 76-mm (3-in) gun, and four 457-mm (18-in) torpedo tubes (bow) with eight torpedoes
Complement: 28



The 'O' class were typical of the submarines constructed in America before the USA entered the war. Displacing just over 500 tons, they carried a crew of 28 and were fitted with four 457-mm (18-in) torpedo tubes.

FRANCE

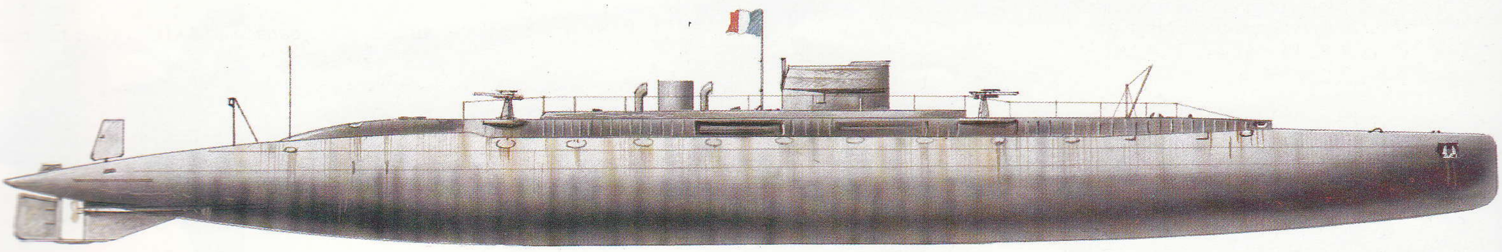
'Dupuy de Lôme' class

At the outbreak of war in 1914 France had over 120 submarines in service. Many were obsolete, however, and more modern examples were so plagued by mechanical trouble as to spend long periods under repair. One cause was an insatiable urge to experiment in design without consolidating on proven technology. Steam propulsion was popular from an early date and remained so for surface navigation, largely because of the unreliability of French-designed diesels of that date. 'Overseas'-type boats were more numerous than in the Royal Navy, their size being sympathetic with Laubeuf double-hulled construction, with the outer hull configured for running on the surface. Diving took typically five minutes but this was not thought to be detrimental and an acceptable tradeoff for seaworthiness. Steam propulsion in itself was a handicap in diving, with the boilers having to be shut down, funnels secured and blanked-off, and electric propulsion run up.

The early 'Pluviôse' type sea-going boats of 1907-10 had two sets of triple-expansion steam engines, and all their torpedoes were carried in the unsatisfactory external drop-collars rather than tubes. They were followed by one-off larger steam-propelled boats, the generally similar *Archimède* of 1909 and the improved *Gustave Zédé* of 1913. The latter had two tubes for torpedoes but retained dropping gear, as did the ultimate pair, the **'Dupuy de Lôme' class** boats, *Dupuy de Lôme* and *Sané* of 1915-6. Like all French submarines, they were constructed in state dockyards, in this case at Toulon. Their size enabled them to maintain 17 kts on the surface but it must be doubtful if they ever reached their claimed 11 kts submerged. After the war they were re-engined with 895-kW (1,200-bhp) diesels removed from ceded German boats. This gave them a greatly increased radius and more internal space as a result of the compactness of the machinery. They also received eight torpedo tubes and served through until 1935.

Specification
'Dupuy de Lôme' class (as built)
Displacement: 833 tons surfaced and 1,287 tons dived
Dimensions: length 75.00 m (246 ft 1 in); beam 6.40 m (21 ft 0 in); draught 4.60 m (15 ft 1 in)
Propulsion: two sets of triple-expansion steam engines delivering 1305 kW (1,750 ihp) and two electric motors delivering 611 kW (820 hp) to two shafts
Speed: 17 kts surfaced and 8 kts dived
Range: 4250 km (2,640 miles) at 10 kts surfaced (after re-engineering), and 200 km (124 miles) at 5 kts dived
Armament: one 75-mm (2.95-in) gun, one 47-mm (1.85-in) gun, and 10 450-mm (17.7-in) torpedoes
Complement: 43

Serving with the Morocco flotilla of the French navy in 1917-18, based at Gibraltar, Dupuy de Lôme ***was an enlarged version of the successful 'Archimède' design. She reached 19 kts on her reciprocating engines on trials. These engines were replaced after the war by a 1200-bhp Krupp diesel taken from an ex-German submarine.***



UK

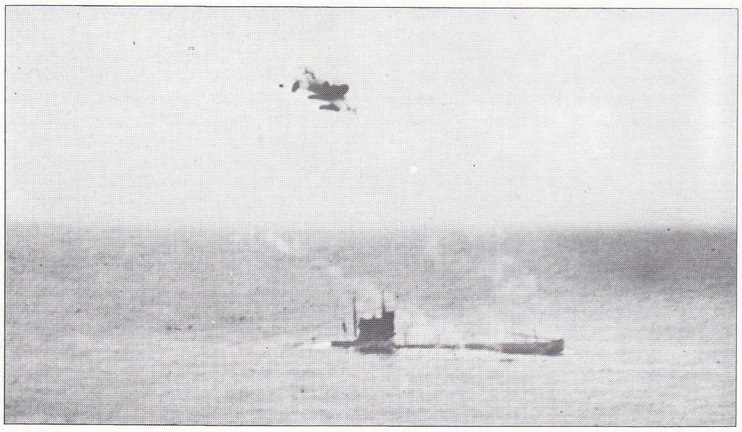
'C' class

As a lengthened and improved 'B' class, the **'C' class** submarines ran to the considerable number of 38 boats though, in the four years of their construction programme, various improvements were incorporated. In practice there were two main groups, *C1* to *C18* (completed 1906-8) and *C19* to *C38* (completed 1909-10). Costing something like £47,000 to £50,000 each, all except six were built by Vickers, which firm had the monopoly of constructing, in concert with the Royal Dockyards, any submarine for which the company had provided the major design input. The hull design was of spindle form with poor characteristics on the surface (where the boats of the day spent the greater part of their time). It is interesting that the concept of these early forms, which were aimed at the best submerged performance, was gradually abandoned over the years, to be readopted and refined only in the high-speed submarine developments post-1950. Improvements to both casing and tower resulted not only in better seakindliness but also in increasing periscope length from 3.76 m (12 ft 4 in) to 6.40 m (21 ft 0 in), an important consideration with respect to depth-keeping in a sea. In the earlier boats, two periscopes were fitted for the first time.

Reserve of buoyancy was greater than in earlier boats but was still limited, decreasing further over the years to the extent that, eventually, the choice often had to be made between spare torpedoes or fuel capacity. Compared with that of the 'B' class boats, battery power was increased by 50 per cent, but the submerged endurance of 93 km (58 miles) at 4.5 kts still needs to be compared with 37 km (23 miles) at 5 kts for the earliest 'A' boats.

A drawback to all these early classes was their total lack of main internal watertight bulkheads; to reduce the danger of rapid flooding, a collision bulkhead was later fitted to some. Habitability was of a very low standard and the adherence to the petrol engine perpetuated the explosion risk from vapour.

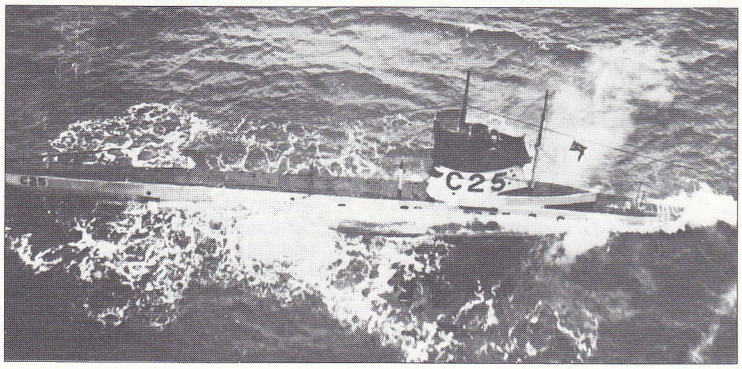
Despite their obvious limitations, the 'C' boats were active in the war. Because of their small size four were shipped to North Russia, broken into sections, transported overland and reassembled for use in the Gulf of Finland. At a time when smaller U-boats were pestering the British North Sea fishing fleet, 'C' boats were occasionally towed submerged by decoy trawlers, a ruse that resulted in the destruction of two of the enemy before detection caused its abandonment. War losses totalled four, and the four boats in the Gulf of Finland were all eventully blown up.



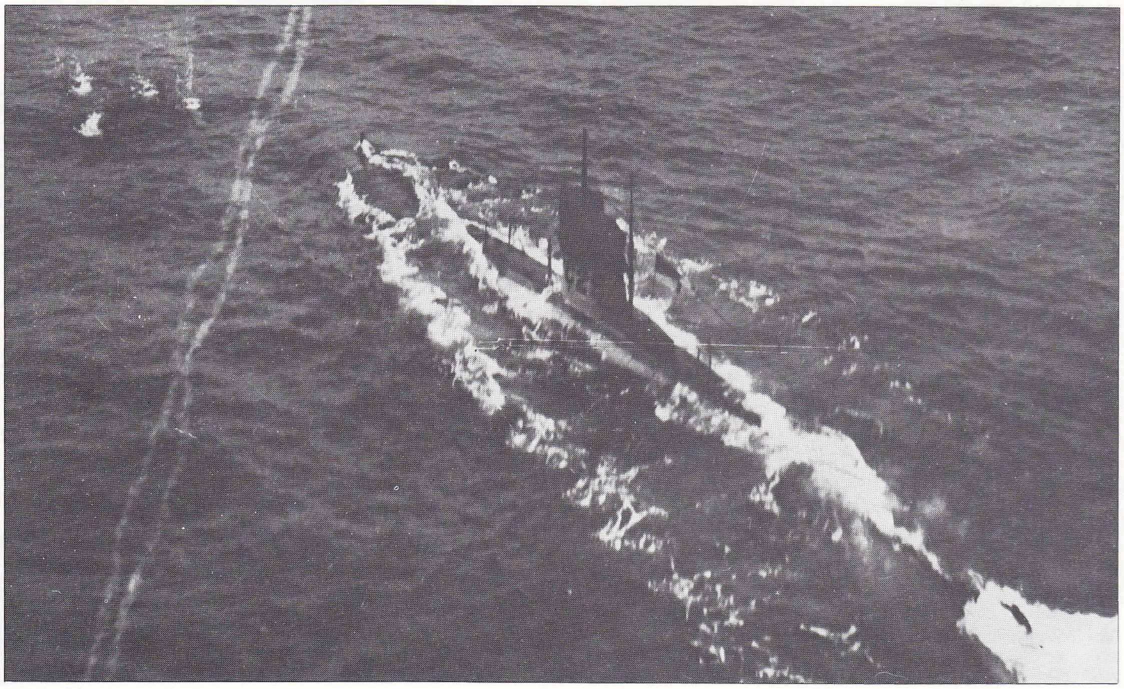
A remarkable series of photos taken from one of Oberleutnant Friederich Christiansen's Hansa-Brandenburg W.29 floatplanes, which attacked C-25 off Harwich on 6 July 1918. The pressure hull was pierced and the CO, Lieutenant Bell, was killed along with five of his crew.

Specification

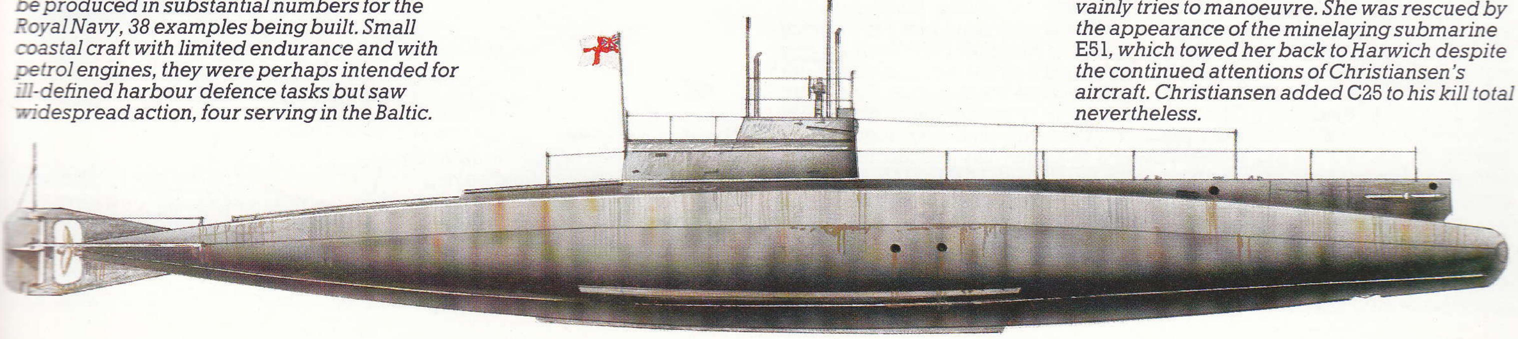
'C' class (second series)
Displacement: 290 tons surfaced and 320 tons dived
Dimensions: length 43.36 m (142 ft 3 in); beam 4.14 m (13 ft 7 in); draught 3.51 m (11 ft 6 in)
Propulsion: one petrol engine delivering 447 kW (600 bhp) and one electric motor delivering 224 kW (300 hp) to one shaft
Speed: 13.5 kts surfaced and 8 kts dived
Range: 2414 km (1,500 miles) at 8 kts surfaced, and 101 km (63 miles) at 5 kts dived
Armament: two 457-mm (18-in) torpedo tubes (both bow) with two or four torpedoes
Complement: 16



Right: The figure by the periscope is believed to be Leading Seaman Barge, who was mortally wounded while firing a Lewis gun back at the aircraft. He shouted for the submarine to dive, unaware that she had already sustained prohibitive hull damage.



Above: Bullets impact into the water as C25 vainly tries to manoeuvre. She was rescued by the appearance of the minelaying submarine E51, which towed her back to Harwich despite the continued attentions of Christiansen's aircraft. Christiansen added C25 to his kill total nevertheless.



The 'C' class of submarine was the first type to be produced in substantial numbers for the Royal Navy, 38 examples being built. Small coastal craft with limited endurance and with petrol engines, they were perhaps intended for ill-defined harbour defence tasks but saw widespread action, four serving in the Baltic.

UK

'E' class

The eight-boat **'D' class**, completed in 1909-12, rectified many of the shortcomings of the 'C' class. Though 5.79 m (19 ft) longer, they were better seaboats and they were also equipped with saddle tanks, which accommodated most ballast capacity outside the pressure hull and increased the reserve of buoyancy. They also had diesel propulsion on twin shafts (so improving manoeuvrability), could carry a 12-pdr gun and shipped a third torpedo tube aft. It was felt that while the design was successful, the 'D' class boats would experience difficulty in getting clear following an end-on torpedo attack at close range, even though fitted with an upper, separate rudder. Two transverse tubes were, therefore, added to a new design to permit beam attacks, and it was the length of these tubes, located amidships, that decided the main dimensions of what was to become the **'E' class**.

Completed from 1913 through to 1916, the 'E' class ran to 55 hulls whose construction, once war was declared, was shared between 13 private yards. They fell into five major groups, differences being primarily in torpedo layout and the adaption of six boats to carry 20 mines in place of their amidships tubes. The stowage of the mines in external vertical chutes anticipated later French practice. Two, sometimes three, internal bulkheads were added, increasing the safety margin but giving problems in reloading the forward tubes.

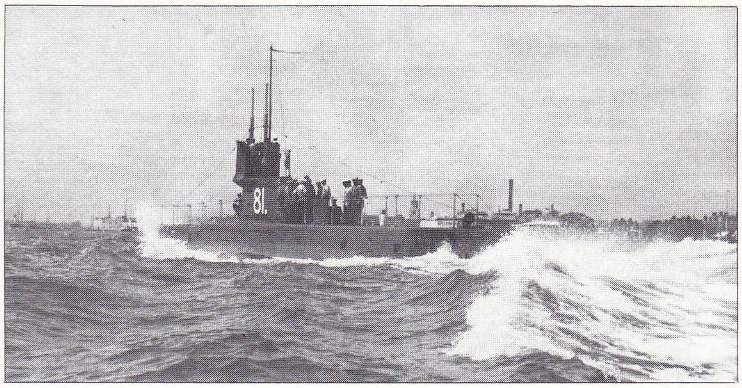
The diesels fitted were of Vickers' own design, usually built under licence. They were single-acting, four-stroke units with blast injection, started by either compressed air or electric motor. In the 'D' class the engines had six cylinders and in the 'E' class eight.

With their heavy operational involvements, the 'E' class boats had an important yet extraordinarily varied surface armament. Early boats had nothing or one 2-pdr, while later examples had both a 12- and 2-pdr. One, *E20*, was fitted with a 152-mm (6-in) howitzer. Improvements necessary for longer-range radio communication required some 'E' class boats to surrender an amidships tube to make room for a wireless telegraphy cabinet.

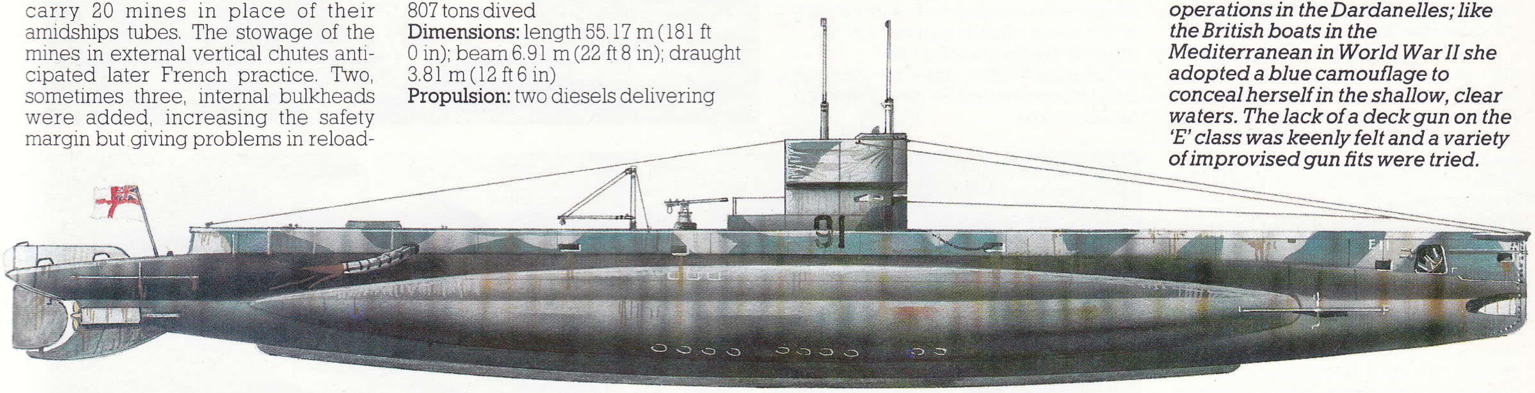
The class was active in the North Sea, Baltic and eastern Mediterranean. Just before Jutland, *E22* became one of the earliest submarines to carry aircraft, in the course of experimenting with Sopwith seaplanes for operations against Zeppelins. Some 22 of the boats were lost in World War I.

Specification

'E' class ('E21' type)
Displacement: 667 tons surfaced and 807 tons dived
Dimensions: length 55.17 m (181 ft 0 in); beam 6.91 m (22 ft 8 in); draught 3.81 m (12 ft 6 in)
Propulsion: two diesels delivering 1193 kW (1,600 bhp) and two electric motors delivering 626 kW (840 hp) to two shafts
Speed: 14 kts surfaced and 9 kts dived
Range: 6035 km (3,750 miles) at 10 kts surfaced, and 121 km (75 miles) at 5 kts dived
Armament: one 12-pdr gun , and five 457-mm (18-in) torpedo tubes (two bow, two amidships and one stern) with 10 torpedoes
Complement: 30



In 1911 the Admiralty ordered six enlarged 'D' class submarines. This modified design became known as the R-1 group; eight were built for the Navy and two for Australia. E1, seen here, was shipped to Murmansk and taken overland to operate in the Gulf of Bothnia and the Baltic. She was eventually scuttled at Helsingfors in April 1918 to avoid capture by the advancing Germans.



E11 as she appeared during her operations in the Dardanelles; like the British boats in the Mediterranean in World War II she adopted a blue camouflage to conceal herself in the shallow, clear waters. The lack of a deck gun on the 'E' class was keenly felt and a variety of improvised gun fits were tried.

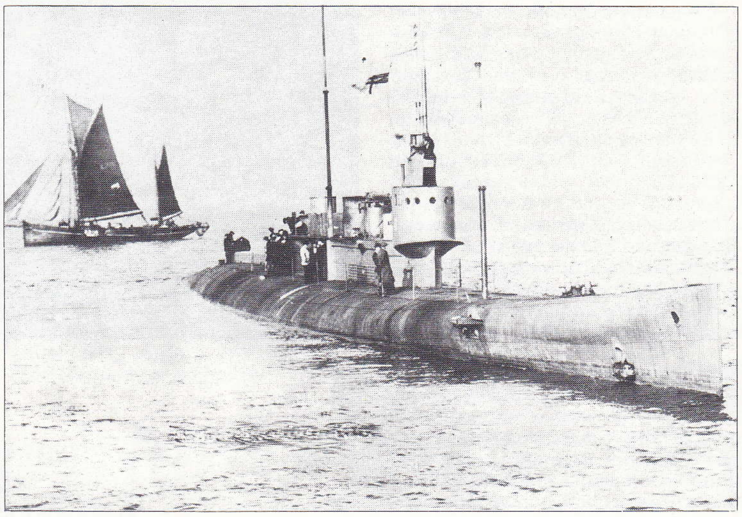
UK

'K' class

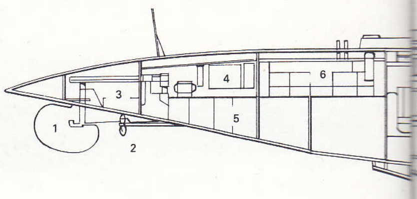
With HMS *Swordfish* building but anticipated to reach nothing like her designed surface speed, there came a requirement direct from the Grand Fleet for a class of 24-kt submarines to work tactically with surface forces. Such a speed was quickly demonstrated to need 7457 kW (10,000 shp) on a surface displacement of 1,700 tons. No contemporary diesels could deliver such power from anything less than eight units, and there was thus no alternative to steam. With two boilers and a turbine room the hull of the **'K' class** needed to be of a good size but, with the poor economy of steam plant and the need to provide power when steam was shut down, a 597-kW (800-bhp) diesel was also installed to drive a generator. This could either charge the batteries or power the main drive motors for a surface speed of about 9.5 knots. Over one-third of the hull was thus devoted to machinery. The two funnels exhausting the boilers hinged downward into the casing before a dive was commenced, their orifices being simultaneously shut off by sealing plates. Diving took up to five minutes.

While 533-mm (21-in) torpedo tubes were specified for the class, they could not be made available in time and 457-mm (18-in) tubes were fitted except in the single improved boat, *K26*, completed in 1923. Four fixed athwartships tubes were sited in a torpedo room immediately forward of the boiler space and two further, trainable tubes (later removed) were set behind screens in the large superstructure, for use in surface action. Two 102-mm (4-in) guns were mounted at (usually) lower casing level, with a 76-mm (3-in) high-angle gun sited on the superstructure, but individual armament fits varied. Some 17 boats were completed in 1917 and 1918.

The 'K' class boats met the fleet requirements for surface speed but needed the addition of a flared and bulbous bow casing (known euphemistically as a 'swan bow') to maintain speed in any sea. Such hard driving damaged bow shutters and, more critically, funnel mechanisms. The boats' complexity made them extremely troublesome, and they acquired an evil name, not fully justified. In particular, the so-called Battle of May Island in January 1918, when two were lost in collisions, demonstrated the underlying fallacy of operating large submarines on the surface in high-speed fleet manoeuvres at night, not shortcomings in the boats themselves.



Above: K6 is seen before the addition of the ungainly bow casing, politely termed the 'swan bow'. Sealing the boat before diving proved difficult, as ventilators could be jammed open by only a small obstruction. The planned 21-in torpedoes were abandoned in favour of 18-in ones.

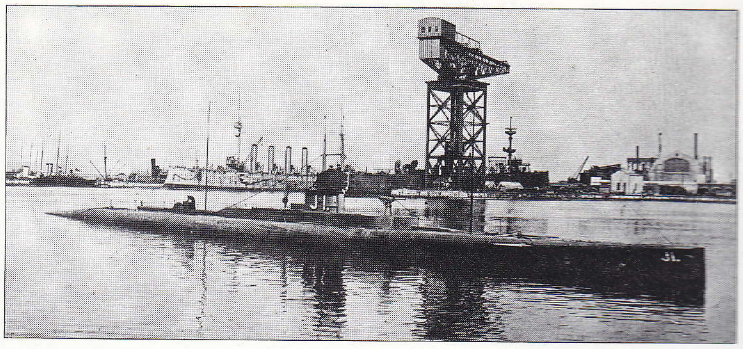


UK

'J' class

In 1912 requirements were framed for likely future types of submarine, and these included an 'overseas' craft, of an appropriate size and habitability for extended operations. It was hoped to achieve a speed of 21 kts on the surface which, in conjunction with a double-hulled design (the outer of which could be given a suitable configuration unrestricted by the pressure-tight requirements of the inner hull) would enable it to operate with the main body of the fleet. A prototype, HMS *Nautilus*, was built by Vickers and completed in 1917 in slow time. The company produced two new 1380-kW (1,850-bhp) diesels for the purpose, but it was apparent from model testing that the boat would never be able to exceed 17 kts. For this reason, Scotts were given the task of building a steam-propelled alternative in HMS *Swordfish*. Both were very large boats compared with the 'E' type but experience with them was still lacking and, as longer-range submarines were needed, it was decided to follow German practice and build a smaller double-hulled design without the requirement for a high surface speed. This was the 14-strong **'G' class**.

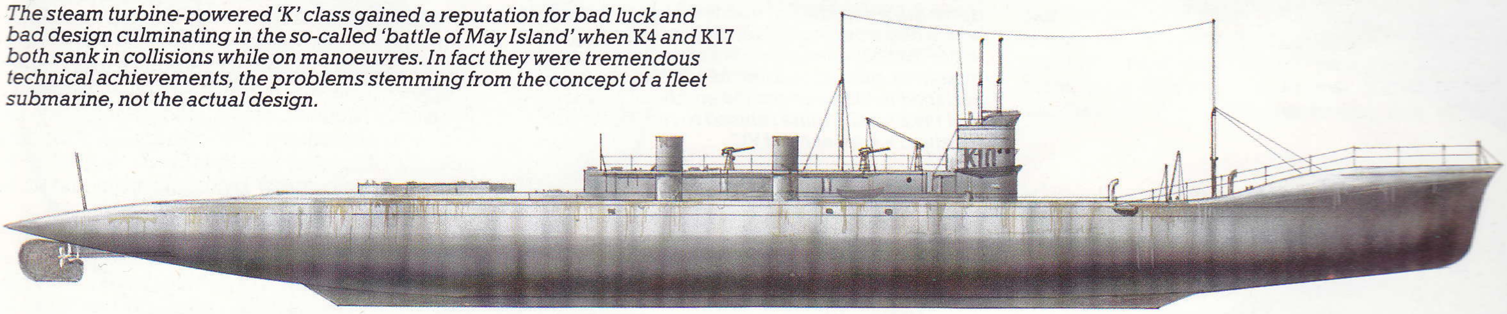
The two, experimental boats were still incomplete when it became known (incorrectly) that the Germans were building a 22-kt class, and there was suddenly a pressing need to match them. Existing machinery had to be used and, with the largest available diesel being the 12-cylinder 895-kW (1,200-bhp) Vickers unit, three of these were incorporated in what became the 'J' class. These were the longest boats yet and could manage over 19 kts on the surface. To attain the necessary fineness of line the seven boats (six completed in 1916 and one in 1917) were double-hulled over only some 56 per cent of their length. This length was determined largely by the demands of the machinery, though only the wing shafts were driven when submerged. Their beam needed to accommodate the two transverse amidships tubes and the pressure hull itself needed to be locally bulged to suit. They were the first British submarines with four tubes forward and a unique arrangement aft allowed the *J1* (only) to release depth charges. Only one was lost and that by accident to the 'Q' ship HMS *Cymric* just before the Armistice. The remainder were transferred to the Royal Australian Navy.



The handful of 'J' class boats was one of several attempts to produce a 'fleet submarine': that is, a submarine capable of over 20 kts able to operate in conjunction with the battlefleet. J1 *was later fitted to drop depth charges from her after casing.*

Specification
'J' class
Displacement: 1,204 tons surfaced and 1,820 tons dived
Dimensions: length 83.97 m (275 ft 6 in); beam 7.01 m (23 ft 0 in); draught 4.27 m (14 ft 0 in)
Propulsion: three diesels delivering 2685 kW (3,600 bhp) and two electric motors delivering 1007 kW (1,350 hp) to three shafts
Speed: 19.5 kts surfaced and 9.5 kts dived
Range: 9254 km (5,750 miles) at 10 (?) kts surfaced, and 101 km (63 miles) at 5 kts dived
Armament: one 76- or 102-mm (3- or 4-in) gun, and six 457-mm (21-in) torpedo tubes (four bow and tow amidships) with 12 torpedoes
Complement: 44

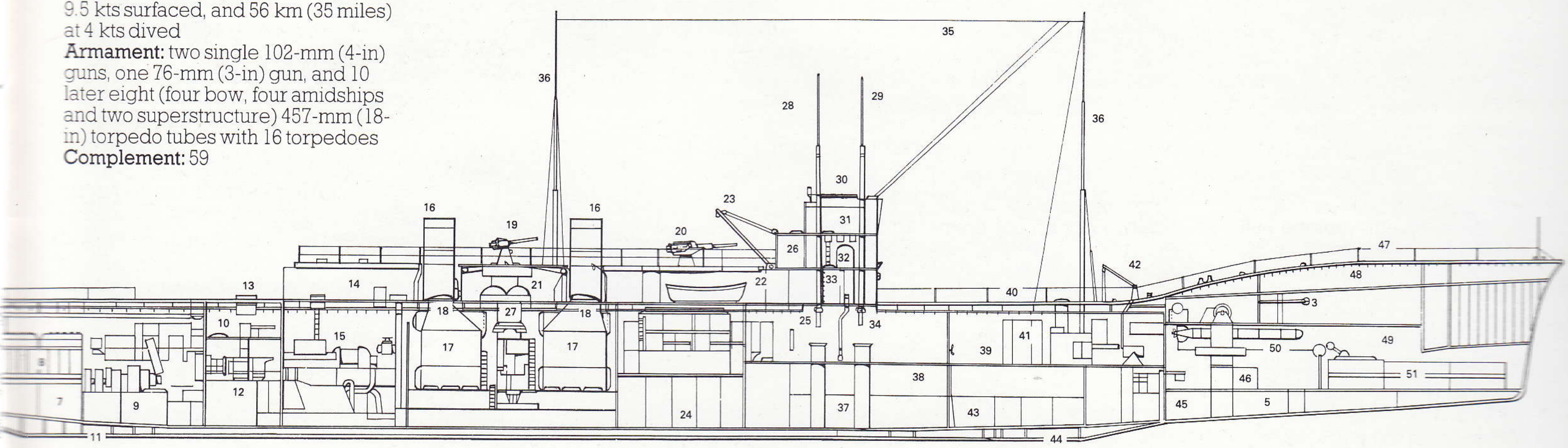
The steam turbine-powered 'K' class gained a reputation for bad luck and bad design culminating in the so-called 'battle of May Island' when K4 *and* K17 *both sank in collisions while on manoeuvres. In fact they were tremendous technical achievements, the problems stemming from the concept of a fleet submarine, not the actual design.*

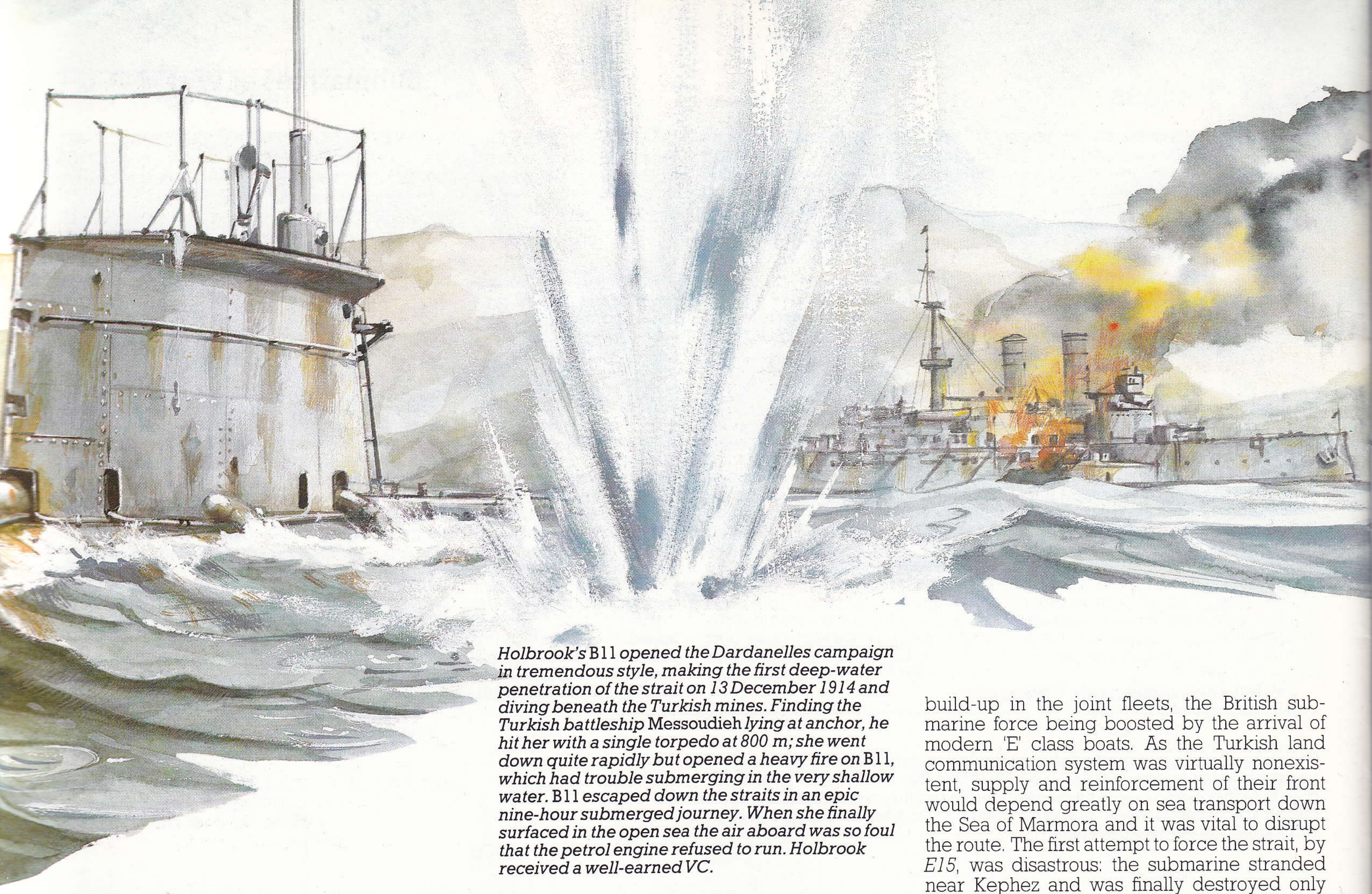


Specification
'K' class
Displacement: 1,980 tons surfaced and 2,566 tons dived
Dismentions: length 103.32 m (339 ft 0 in); beam 8.10 m (26 ft 7 in); draught 5.18 m (17 ft 0 in)
Propulsion: two sets of geared steam turbines delivering 7830 kW (10,500 shp) or one diesel delivering 597 kW (800 bhp) via a generator, and two electric motors delivering 1074 kW (1,440 bhp) to two shafts
Speed: 24 or 9.5 kts surfaced (steam or diesel) and 8.5 kts dived
Range: 23175 km (14,400 miles) at 9.5 kts surfaced, and 56 km (35 miles) at 4 kts dived
Armament: two single 102-mm (4-in) guns, one 76-mm (3-in) gun, and 10 later eight (four bow, four amidships and two superstructure) 457-mm (18-in) torpedo tubes with 16 torpedoes
Complement: 59

Modified 'K' class submarine cutaway drawing key

1 Rudder
2 Twin screws
3 Hydroplanes
4 Steerage compartment
5 Trim tanks
6 Crew compartment
7 Engine room
8 Eight-cylinder diesel engines
9 Main motor
10 Motor control room
11 10-ton aft keel weight (to be dropped in emergency)
12 Gearbox
13 Escape hatch
14 Superstructure
15 High-pressure/low-pressure steam turbine
16 Hinged funnel
17 Oil-fired boiler
18 Hatches (closed when submerged)
19 Three-inch AA gun
20 Four-inch gun
21 Hinged air intakes
22 Dinghy
23 Derrick for boat handling or stowing torpedoes
24 Battery compartment
25 Control room
26 Conning tower
27 Forced draft fan
28 Search periscope
29 Attack periscope
30 Bridge with streamlined screen
31 Wheelhouse
32 Dome
33 Hatch
34 Compass tube
35 Wireless aerial
36 Retractable wireless mast
37 Periscope wells
38 Batteries
39 Inner pressure hull
40 Double hull
41 Crew mess area/quarters
42 Derrick
43 Ballast tanks
44 10-ton forward keel weight
45 Auxiliary ballast tanks
46 Air bottles
47 Raised swan bow
48 Buoyancy chamber
49 Torpedo room
50 18-inch torpedoes
51 Torpedo tubes





Holbrook's B11 *opened the Dardanelles campaign in tremendous style, making the first deep-water penetration of the strait on 13 December 1914 and diving beneath the Turkish mines. Finding the Turkish battleship* Messoudieh *lying at anchor, he hit her with a single torpedo at 800 m; she went down quite rapidly but opened a heavy fire on* B11*, which had trouble submerging in the very shallow water.* B11 *escaped down the straits in an epic nine-hour submerged journey. When she finally surfaced in the open sea the air aboard was so foul that the petrol engine refused to run. Holbrook received a well-earned VC.*

Victory in the Straits

The Turkish fleet had good reason to feel safe in 1914; although it was committed to war with the world's most powerful navy, its vessels sheltered at the end of the Sea of Marmora, a hundred miles of shallow waters with treacherous currents, sown with mines and protected by forts. Yet Allied submariners took up the challenge and sailed their frail craft into the straits, one British boat entering Constantinople itself.

When on 30 October 1914 Turkey declared for the Central Powers, business began in earnest for a small Anglo-French submarine force based on the Greek island of Tenedos. Handily-placed close to the entrance to the Dardanelles, the boats had been familiarizing themselves with the approaches ever since the German battle-cruiser *Goeben* and light cruiser *Breslau* had disappeared up the strait in the previous August. Together with the makeshift depot ship *Hindu Kush* were, initially, three French boats and the British *B9*, *B10* and *B11*.

The Dardanelles is a narrow strait about 58 km (36 miles) in length and leads to the land-girt Sea of Marmora, about 160 km (100 miles) from end to end. At the far end of this water was the magnet of the Turkish capital, Constantinople, but to reach it a submarine had to negotiate the strait, which was heavily defended by forts, batteries and searchlights, its waters possessing unpredictable currents of up to 5 kts at the Narrows and also strewn with nets and mine barriers.

Of the Allied submarines, Holbrook's *B11* had been recently equipped with new batteries and was elected to make the first deep penetration of the strait. Thus on 13 December 1914, equipped with improvised mine guards, the little boat dived inside Cape Helles just before daylight. Holbrook kept to the European side to cheat the tide and (except when taking frequent periscope checks) ran as far as possible at 18 to 24 m (60 to 80 ft) to keep below the mines. Four hours after going down and after various alarms and excursions, *B11* had negotiated the first mine barriers off Kephez and was approaching the second, below the Chanak narrows. To his delight, her commander sighted the aged armoured cruiser *Messoudieh* lying unconcernedly at anchor. Considering the date and conditions, his hitting her with a single torpedo at the range of 800 m (880 yards) was a fine feat. She settled rapidly but opened a brisk fire on the submarine, which was experiencing difficulty in remaining hidden in very shallow water. With no compass, Holbrook bumped and bored his way back down the iron gullet of the strait. Successful, he surfaced in the open sea after nine hours submerged, the air in the boat so foul that his petrol engine refused to run. The obsolete little boat had opened unlimited prospects, and her commander received a well-merited Victoria Cross.

With the opening of the main Dardanelles campaign early in 1915, there was a rapid build-up in the joint fleets, the British submarine force being boosted by the arrival of modern 'E' class boats. As the Turkish land communication system was virtually nonexistent, supply and reinforcement of their front would depend greatly on sea transport down the Sea of Marmora and it was vital to disrupt the route. The first attempt to force the strait, by *E15*, was disastrous: the submarine stranded near Kephez and was finally destroyed only after a heroic foray by boats from the battleships HMS *Majestic* and *Triumph*.

It fell to the Australian boat *AE2* to be the first through the strait, on 25 April 1915, followed the very next day by *E14* which bored through mainly on the surface, taking advantage of darkness. Strong nerves were required as the boat was held by the cold fingers of the searchlights and subjected to a continuous bombardment. Boyle, the commander, submerged when things became too hot but, finding the scraping of mine cables along the hull even more unpleasant, kept popping up. Like the Australian, Stoker before him, Boyle found a gunboat to torpedo but, in the process, had a periscope shot through and the other grasped rudely by a Turk in an open boat!

Australian vessel sunk

Activity was intense, it being the third day before Boyle could fully charge his batteries. He was rewarded by being able to force aground one of two transports under destroyer escort. The same evening he met up with *AE2*, which was down to one torpedo, having had the cruel experience of firing six duds. On the very next day the Australian was caught on the surface by a Turkish destroyer and sunk.

The British boat had a lean time, for the Turks cut their sailings to a minimum and put refugees on those that did move so that they could not be sunk. Then, the first legitimate target was hit by a torpedo that failed to explode. At last on 10 May Boyle sank a laden troopship hard by Constantinople and, reduced to one faulty torpedo (he had no deck gun), he then harassed local shipping for a week with threats and rifle fire until recalled on 17 May. Hunted persistently whilst coming down the strait with the stream, he avoided much trouble by passing the various barriers close astern of an enemy patrol. He returned after a 22-day absence with much intelligence regarding the defences and anti-submarine measures, to be awarded the second Victoria Cross gained by the force. During his time away, two French submarines had attempted the passage; of these the *Bernouilli* was unable to stem the current and was forced to return while the *Joule* was sunk in a minefield. Two more French boats, the *Saphir* and *Mariotte*, were also to be lost, similarly or following technical troubles.

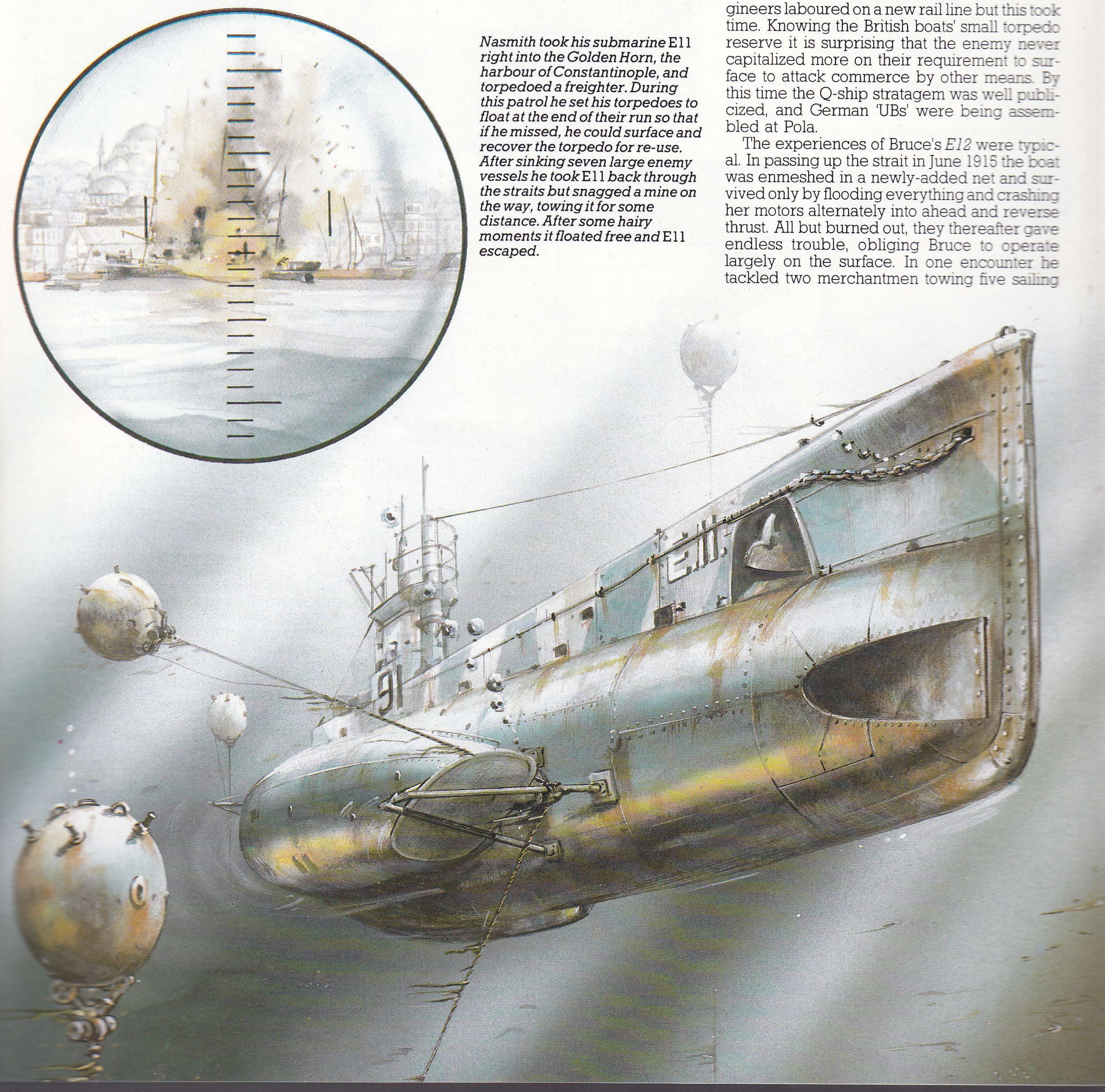
Boyle was immediately relieved by Nasmith in the *E11*, the latter already a veteran of North Sea operations. Profiting by the *E14*'s experiences, Nasmith negotiated the Dardanelles successfully and made for the eastern end of the Sea of Marmora. He, too, began by sinking a Turkish patrol craft which also succeeded in putting a 6-pdr shot through his periscope. This was followed by a couple of transports, the loss of which caused traffic to cease. Nothing daunted, Nasmith took the *E11* right into the Golden Horn, the harbour of Constantinople, and torpedoed a freighter alongside the arsenal.

The lack of a deck gun was keenly felt and transports were sunk by demolition charge whenever possible. Nasmith developed the technique of setting his torpedoes to float at the end of their run, so that 'misses' could be later recovered, disarmed and manoeuvred carefully back into the bow tubes with the boat suitably trimmed, a precarious business that left them very vulnerable for a time. Even when torpedoed, however, a large well-found ship could survive the explosion of a 457-mm (18-in) warhead, and several were thus beached. Sailing craft were burned in numbers. Not until 7 June did the condition of the *E11*'s machinery oblige withdrawal, the passage down the strait seeing another ship torpedoed and a mine towed for some distance, its cable caught in a hydroplane. Nasmith's extended cruise had bagged seven large ships and earned a further Victoria Cross.

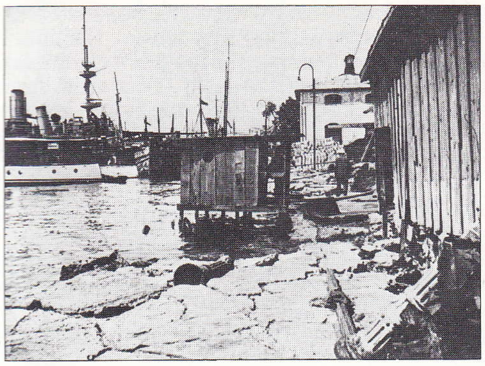
British sub penetration

Despite the fact that the Turks and Germans continuously improved the Dardanelles defences, the Sea of Marmora was inhabited by at least one British submarine throughout 1915. Maritime traffic, though hard hit and often stopped had, of necessity, always to resume because of the endless needs of the front and the dreadful land communications. German engineers laboured on a new rail line but this took time. Knowing the British boats' small torpedo reserve it is surprising that the enemy never capitalized more on their requirement to surface to attack commerce by other means. By this time the Q-ship stratagem was well publicized, and German 'UBs' were being assembled at Pola.

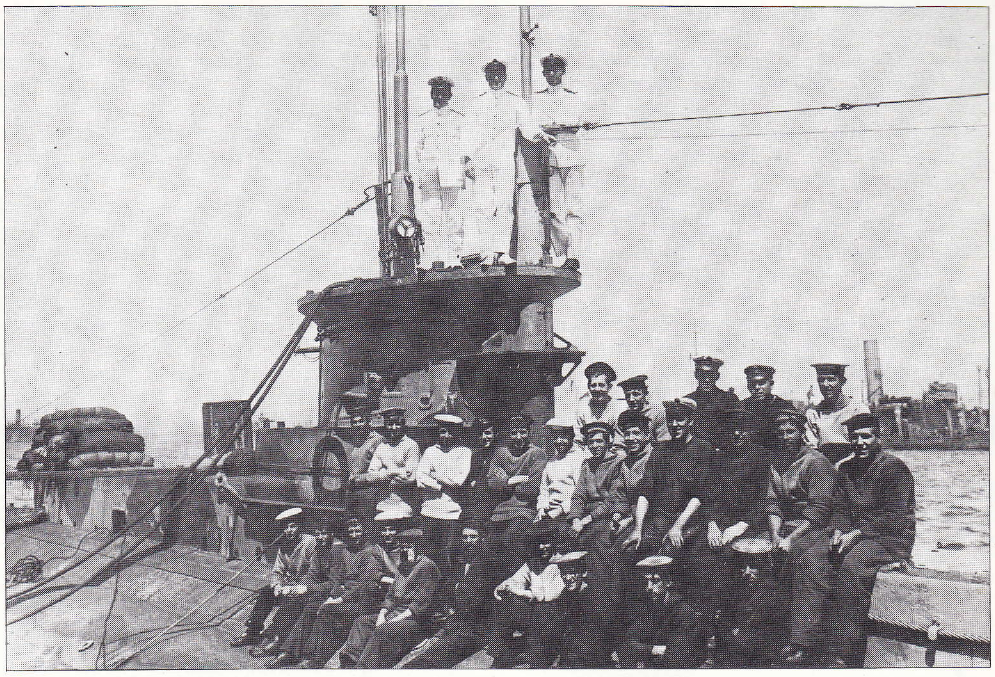
The experiences of Bruce's *E12* were typical. In passing up the strait in June 1915 the boat was enmeshed in a newly-added net and survived only by flooding everything and crashing her motors alternately into ahead and reverse thrust. All but burned out, they thereafter gave endless trouble, obliging Bruce to operate largely on the surface. In one encounter he tackled two merchantmen towing five sailing



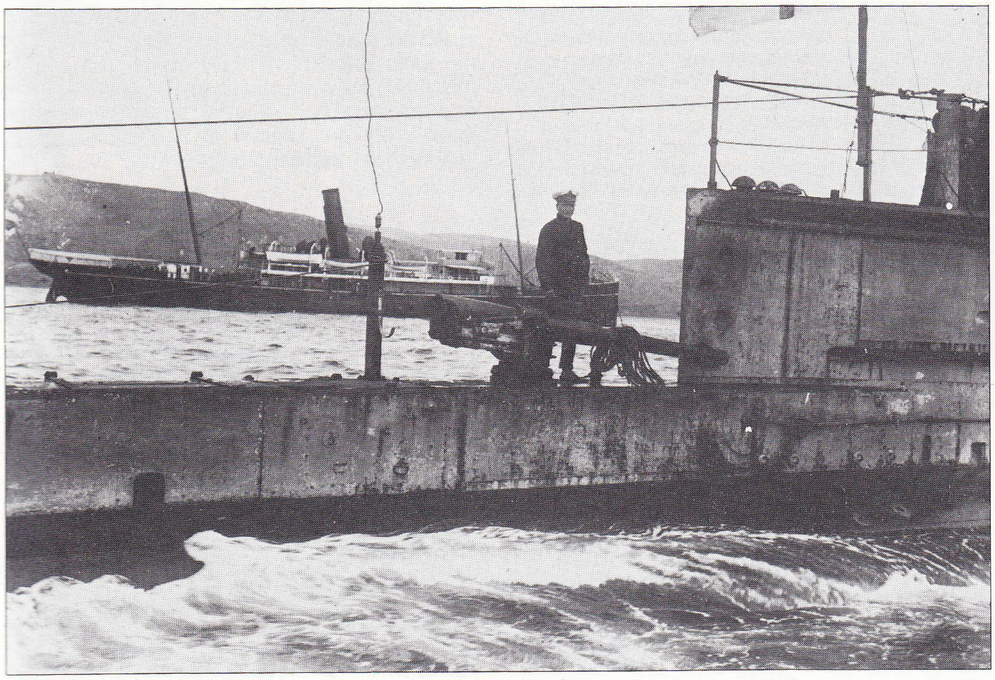
Nasmith took his submarine E11 *right into the Golden Horn, the harbour of Constantinople, and torpedoed a freighter. During this patrol he set his torpedoes to float at the end of their run so that if he missed, he could surface and recover the torpedo for re-use. After sinking seven large enemy vessels he took* E11 *back through the straits but snagged a mine on the way, towing it for some distance. After some hairy moments it floated free and* E11 *escaped.*

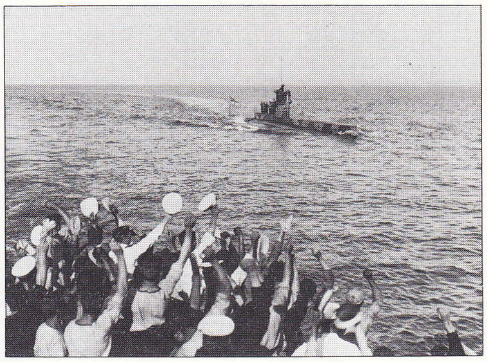


Above: The waterfront in Constantinople is seen after the British submarine E11*, commanded by Nasmith, entered the harbour and unleashed a salvo of torpedoes, sinking a large merchantman and shattering this section of dock. Nasmith even took time to take a photograph through his periscope to record his visit for posterity.*



Right: The straits had dangerous currents and were heavily mined by the Turks; passing through on the surface meant braving the powerful forts. Here the triumphant crew celebrate their return. Note the damage to the periscope.





Above:* E11 *returns from her most successful patrol, having sunk the Turkish battleship* Heireddin Barbarossa *on 8 August 1915. The battleship (ex-German 'Brandenburg' class,* Kurfürst Friedrich Wilhelm*) had had an active career in Ottoman service, fighting the Greek fleet in 1912-3, when she was the Turkish flagship.

Left: The commander of* E2 *poses by his gun after returning from a successful patrol in the Sea of Marmora.* E2 *began life with a 12-pdr weapon but received a 4-in gun at Malta.

craft. Spurning the aid of his toy 6-pdr he ran alongside one ship, only to have somebody above heave a bomb at him (it bounced off the foredeck without exploding) and direct a sustained fusillade of rifle fire. In a very exposed situation, Bruce had his gun crew put shots along the length of the ship's hull at a range where half-bricks would have been more appropriate. Simultaneously, others of his crew used rifles to fight off two of the tows, which were endeavouring to snare his propellers with a cable. After a Henty-type scrap the submarine disposed of its tormentors and pursued the second ship until it ran under the protection of a shore battery.

As the 'E' boats gained 12-pdr guns they developed also a taste for annoying targets ashore, duelling with artillery and shelling such railways as existed. During the August, Nasmith and Boyle, in *E11* and *E14*, shared a particularly fruitful patrol. Off Gallipoli town the *E11* sank the Turkish battleship *Heireddin Barbarossa*, following which her first lieutenant, d'Oyly Hughes, swam ashore one night and blew up a railway line. Hotly pursued by the vengeful enemy, he was fortunate to survive the escapade.

The Sea of Marmora remained no sinecure. In the September *E7* had to be scuttled after having become hopelessly fouled by nets off Nagara. Of the French submarines, only the *Turquoise* ever succeeded in negotiating the strait, operating in the Sea of Marmora for a short period in October 1915. Returning, however, she stranded and was captured intact. Not only did the Turks recommission her (as the *Mustadieh Ombashi*) but her papers compromised a planned rendezvous with the British *E20*, which was thus simply ambushed by the German *UB-14*, torpedoed and sunk with all but nine of her crew.

Only Nasmith in the E11 was then left in the Sea of Marmora but, in a cruise of 47 days, he created such mayhem that he was rewarded by promotion to captain's rank after only one year as a commander. In mid-December he was joined by Stock's *E2*, which was the final boat in the area as the decision to abandon the whole Dardanelles campaign had been taken. When this boat returned down the strait on 2 January 1916 some obstructions had already been removed and the Allied evacuation was almost complete.

For the loss of four British and four French boats, the force had proved that submarines could sustain an effective campaign in disputed waters. In addition to disruption ashore, they had sunk two armoured ships, six flotilla ships, 37 merchantmen and nearly 200 assorted sailing craft.

UK

'L' class

With the benefit of war experience, the generally satisfactory 'E' class design was updated, the first pair of the new type being first designated *E57* and *E58* before officially becoming *L1* and *L2* of the new **'L' class**. There were eventually four major subgroups: *L1* to *L8* each had four 457-mm (18-in) tubes in the bows and two more amidships, *L9* to *L33* each had four 533-mm (21-in) tubes forward and two 457-mm tubes amidships (for which they needed to be 2.3 m/7.5 ft longer), six of them minelayers which sacrificed beam tubes for mine chutes, and those from *L52* with a heavier battery of tubes, all forward.

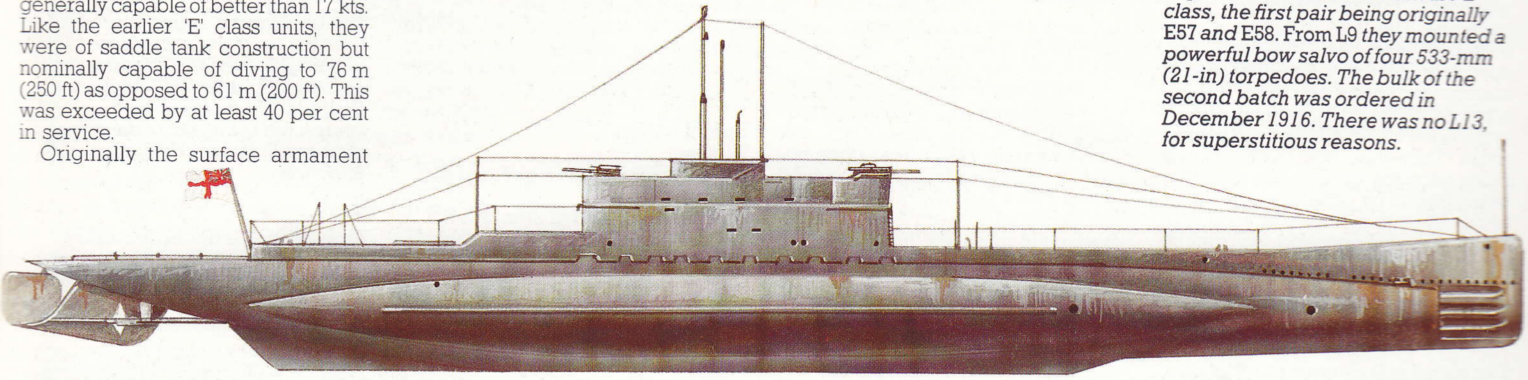
Earlier classes had, almost invariably, disappointed with their poor surface speed and the 'L' class boats were generally capable of better than 17 kts. Like the earlier 'E' class units, they were of saddle tank construction but nominally capable of diving to 76 m (250 ft) as opposed to 61 m (200 ft). This was exceeded by at least 40 per cent in service.

Originally the surface armament was intended to be 76-mm (3-in) guns, but this idea was discarded in favour of a single 76-mm gun forward on a complex 'disappearing' mount that fitted into the bridge front when housed. Only three boats were so fitted before a 102-mm (4-in) gun was adopted on an elevated platform extending forward from the bridge. This height increased the silhouette but enabled the gun to be worked with the submarine in a low-buoyancy condition.

From *L52* the design was refined further, with six 533-mm bow tubes instead of the earlier mix and with two 102-mm guns, both on the superstructure (which needed to be considerably longer) and each served via its own pressure-tight access trunk. The more potent forward torpedo battery enabled the submarine to engage a target at longer range and with a larger slavo. An extra pair of reload torpedoes was also accommodated. Most of the 36 'L' class boats were completed from 1917, too late to have a significant impact on the war; many were cancelled and others not ordered. Two were lost: *L10* to a German destroyer off the Dutch coast and *L55* to a Soviet anti-submarine ship in the Baltic operations of 1919-20. Three (*L23*, *L26* and *L27*) survived to World War II but were used for training.

Specification

'L' class ('L9' type)
Displacement: 914 tons surfaced and 1,089 tons dived
Dimensions: length 72.72 m (238 ft 7 in); beam 7.16 m (23 ft 6 in); draught 4.11 m (13 ft 6 in)
Propulsion: two diesels delivering 1790 kW (2,400 bhp) and two electric motors delivering 1193 kW (1,600 hp) to two shafts
Speed: 17 kts surfaced and 10.5 kts dived
Range: 6679 km (4,150 miles) at 'half full power' surfaced, and 121 km (75 miles) at 5 kts dived
Armament: one 102-mm (4-in) gun, two 457-mm (18-in) torpedo tubes (amidships) and four 533-mm (21-in) torpedo tubes (bow) with 10 torpedoes
Complement: 38



The 'L' class was a substantial improvement over the stalwart 'E' class, the first pair being originally E57 *and* E58. *From* L9 *they mounted a powerful bow salvo of four 533-mm (21-in) torpedoes. The bulk of the second batch was ordered in December 1916. There was no L13, for superstitious reasons.*

UK

'M' class

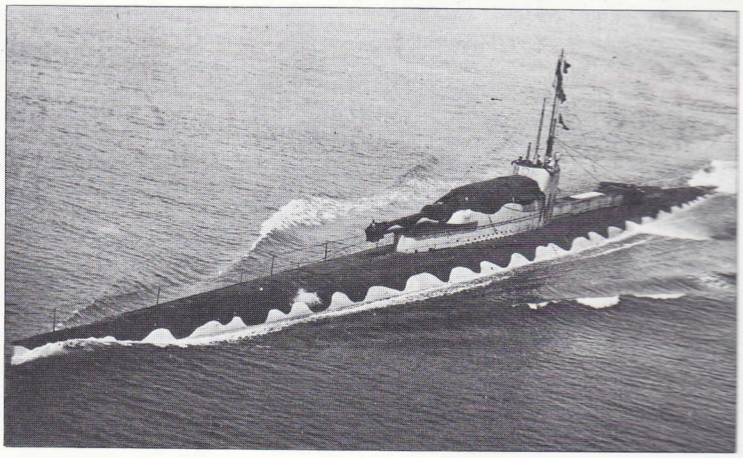
Submarines, more than any other type of warship, spawn oddities from time to time, either as a counter to their considerable limitations or in order to capitalize on their strengths. The quartet of **'M' class** boats, known officially as 'monitor submarines' fall into the former category. World War I submarines had relatively poor submerged performance which, coupled with the lack of speed, range and hitting power of their torpedoes, made the chances of a successful attack on a fast moving and manoeuvring target very slim. It was thought that, by mounting a large gun on a submarine, she could surface unexpectedly and immobilize a target with a single projectile before despatching the target at leisure.

Thus four hulls (*K18* to *K21*) were deleted from the 'K' class programme and replaced by *M1* to *M4*, which were constructed to completely different dimensions. Their design was totally dominated by the 40-calibre 305-mm (12-in) guns removed from pre-Dreadnought battleships, and was double-hulled over about two-thirds of its length. Training of the guns was limited to ±7.5°, and the ship's head needed to be used for coarse adjustment. Elevation was +20° and, once loaded on the surface, the weapon could be fired from periscope depth. A 76-mm (3-in) gun was carried aft for general purposes.

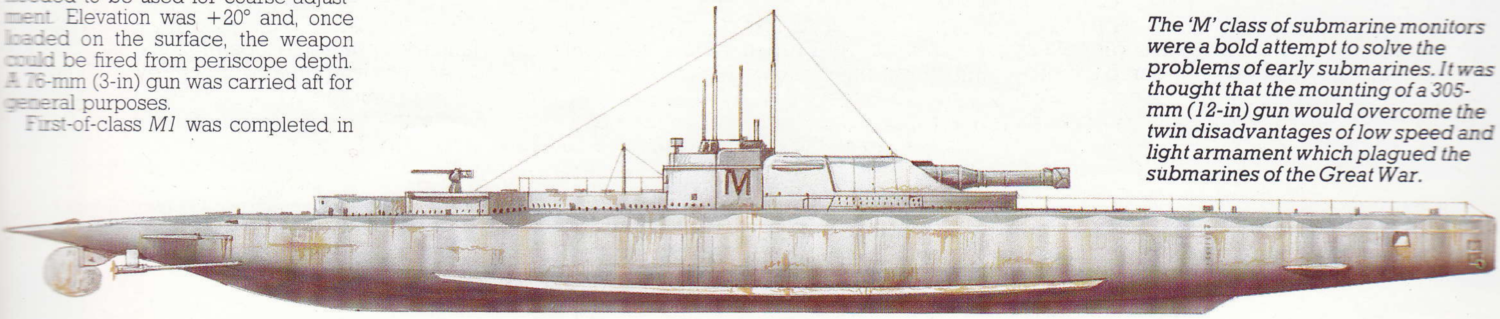
First-of-class *M1* was completed in April 1918, but although she was in the eastern Mediterranean by the Armistice was never used in her designed role. The *M2* and *M3* were completed in 1920 before the Limitations of the Washington Treaty came into force, but they had so little application that the former was converted to carry a small seaplane and the latter into a minelayer in which the mines were stowed in the casing rather than, as previously, in chutes in the saddle tanks. This method was carried on to be used in the Porpoise-class minelayers. The *M4* was never completed. The *M1* was sunk in collision in 1925 and *M2* foundered in 1932.

Specification

'M' class
Displacement: 1,594 tons surfaced and 1,945 tons dived
Dimensions: length 90.14 m (295 ft 9 in); beam 7.52 m (24 ft 8 in); draught 4.80 m (15 ft 9 in)
Propulsion: two diesels delivering 1790 kW (2,400 bhp) and two electric motors delivering 1193 kW (1,600 hp)
Speed: 15 kts surfaced and 9.5 kts dived
Range: 4627 km (2,875 miles) at 15 kts, and 16.7 m (10.4 miles) at 8 kts dived
Armament: one 305-mm (12-in) gun, one 76-mm (3-in) gun, and four 457-mm (18-in) or (*M3* only) 533-mm (21-in) torpedo tubes (bow) with eight torpedoes
Complement: 64



M1 *was the only one of the four-strong class to see war service, although never firing her gun in anger. After the war the concept was abandoned;* M2 *became a seaplane carrier,* M3 *a minelayer, and* M4 *was not completed. Sadly* M1 *was sunk in collision with SS Vidar in 1925 and* M2 *foundered off Portland.*



The 'M' class of submarine monitors were a bold attempt to solve the problems of early submarines. It was thought that the mounting of a 305-mm (12-in) gun would overcome the twin disadvantages of low speed and light armament which plagued the submarines of the Great War.

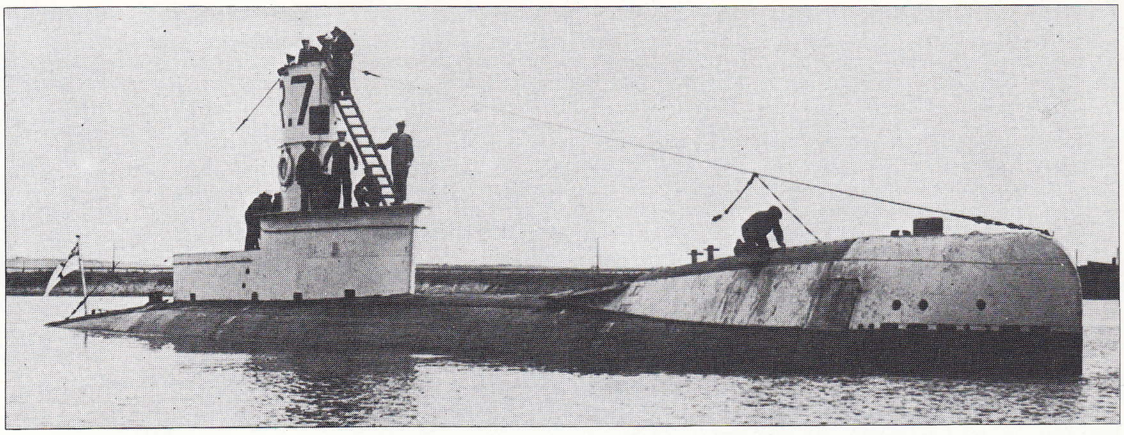
UK

'R' class

Had they not arrived so late in the war, the 10 **'R' class** boats may well have advanced the overall concept and use of submarines considerably. They were designed from the outset as hunters of U-boats which, in these early days of electronics, needed to be attacked on the surface. It was, of course, difficult to approach surfaced U-boats unseen and, once these had observed an enemy and had submerged, it was virtually impossible to detect them again. The 'L' class boats, then (1918) entering service, carried a 10-mm (4-in) gun in the tower for the purpose, but what was needed was to have the speed to approach U-boats submerged, and it was with this in mind that the 'R' class was designed.

Not large boats, they carried a reasonable but not excessive battery capacity. This was allied to a very clean hull which, itself, was largely responsible for their then-phenomenal underwater speed of 15 kts. The design was single-hulled with casing only at the bows and as a fairing to the small tower. They were the first single-shaft boats since the 'C' class, the propeller being driven by either a single diesel or two electric motors in tandem. The torque from the propeller was such as to require horizontal stabilizers aft, these serving also to support the outboard ends of the hydroplanes. An interesting feature was the provision of a further 18.6-kW (25-hp) electric motor right aft for 'creeping' at low speed, repeated in the 'L' class boats.

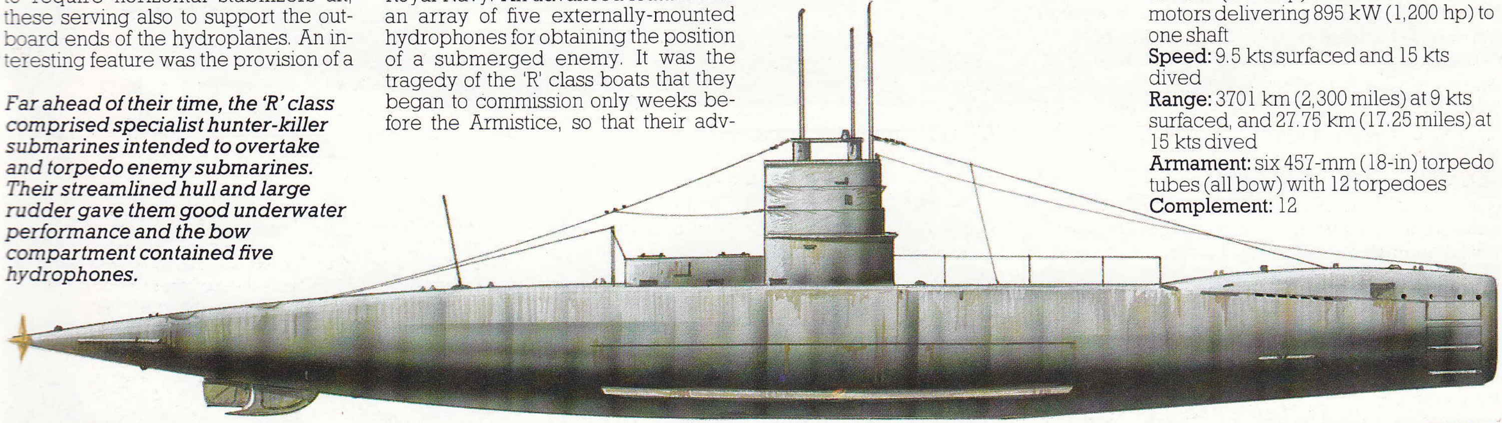
In some, the amidships superstructure was extended forward for the purposes of mounting a 102-mm gun, but as this weapon would have done nothing for the streamlining, it is doubtful if it was ever fitted. The boats relied on their powerful forward battery of six 457-mm (18-in) tubes, the first in the Royal Navy. An advanced feature was an array of five externally-mounted hydrophones for obtaining the position of a submerged enemy. It was the tragedy of the 'R' class boats that they began to commission only weeks before the Armistice, so that their advanced features were never fully appreciated and post-war construction reverted to the cluttered exterior that characterized the 'O' class.



The uncluttered appearance of R7 is in sharp contrast to that of her contemporaries and gave her an outstanding submerged speed. Sadly, the 'R' class was only completed at the end of the war and their revolutionary design passed unnoticed.

Specification

'R' class
Displacement: 410 tons surfaced and 503 tons dived
Dimensions: length 49.91 m (163 ft 9 in); beam 4.80 m (15 ft 9 in); draught 3.50 m (11 ft 6 in)
Propulsion: one diesel delivering 179 kW (240 bhp) and two electric motors delivering 895 kW (1,200 hp) to one shaft
Speed: 9.5 kts surfaced and 15 kts dived
Range: 3701 km (2,300 miles) at 9 kts surfaced, and 27.75 km (17.25 miles) at 15 kts dived
Armament: six 457-mm (18-in) torpedo tubes (all bow) with 12 torpedoes
Complement: 12



Far ahead of their time, the 'R' class comprised specialist hunter-killer submarines intended to overtake and torpedo enemy submarines. Their streamlined hull and large rudder gave them good underwater performance and the bow compartment contained five hydrophones.

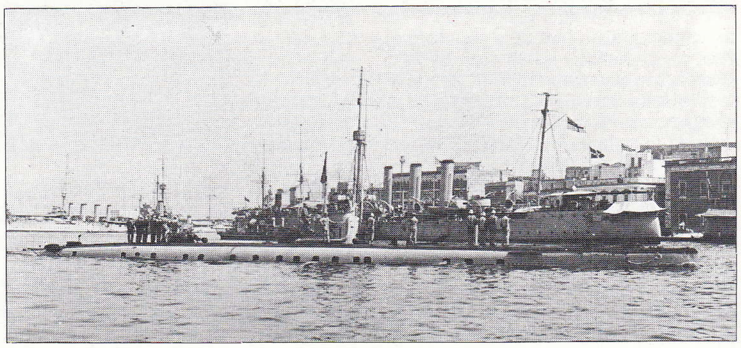
ITALY

'S' class

In its 'D' and 'E' classes, completed from 1910, the British Admiralty changed from the earlier spindle form to the saddle-tanked submarine. Foreign yards had, in the meantime, begun to produce another type with a double hull, i.e. with the pressure hull entirely surrounded by external tank spaces. As this outer hull could be given a shape sympathetic with surface seakeeping, the type was known at this time as a 'submersible', to differentiate it from the earlier 'submarine' in which the outer form was more in harmony with submerged operation. There was much to be said for the idea: ballast tanks and frame could be sited external to the pressure hull, increasing useful space within; with deeper framing, strength was increased; and the flat top of the casing allowed the crew to exercise away from the fetid conditions within the hull. The inherently greater buoyancy reserve of the type was desirable from the safety aspect but had the drawback of sluggish diving.

Laubeuf in France and Laurenti in Italy were foremost in this type of craft and, following a visit in 1911 to Fiat-San Giorgio, the British ordered a single Laurenti from Scotts, followed by a further two in 1913. They were known as the **'S' class** boats *S1* to *S3*, the letter indicating the builder and with the added implication of their being viewed as prototypes. They were only marginally larger than the earlier British 'C' class and were classed as coastal submarines.

Both tubes were sited forward and, to preserve the upper lines of the hull, they were set very low, almost at keel level, the pressure hull adopting an odd cross-section to suit. Indeed, one great failing of the design was the number of discontinuities (and, therefore, weaknesses) in the pressure hull. There were no less than 10 internal watertight bulkheads and the reserve of buoyancy, at 47 per cent, was effectively double that of any previous British boat. The machinery was of Fiat design and, being two-stroke, the engines were capable of direct reversal. An interesting feature was that both forward and after planes could be housed. The boats proved unpopular and unsuitable for the Royal Navy, and were transferred to Italy on the latter's entry into the war in 1915. They were discarded in 1919.



S1 enters Brindisi in 1916. Built in England to an Italian design, she had served for a year with the Royal Navy before being transferred. Similar in size to the British 'C' class, the 'S' boats were slightly slower but had a high reserve of buoyancy.

Specification

'S' class
Displacement: 265 tons surfaced and 324 tons dived
Dimensions: length 45.16 m (148 ft 2 in); beam 4.39 m (14 ft 5 in); draught 3.17 m (10 ft 5 in)
Propulsion: two diesels delivering 485 kW (650 bhp) and two electric motors delivering 298 kW (400 hp) to two shafts
Speed: 13 kts surfaced and 8.5 kts dived
Range: 2960 km (1,839 miles) at 8.5 kts surfaced, and 16 km (10 miles) at 8.5 kts dived
Armament: two 457-mm (18-in) torpedo tubes (bow) with four torpedoes
Complement: 18

Canada

The most significant event in the development of the Canadian military forces since World War II has been their integration and unification in the mid- to late-1960s. In the place of the individual services Canada opted for a single Canadian Armed Forces, which have since undergone a series of reorganizations, restructurings and changes of priority. To most outsiders this restructuring has apparently failed since its impact (coupled with inflation, the rising absolute costs of weapon systems and increases in operating costs) has degraded the overall force levels to about 65 per cent of their former post-war high of 120,000 in the early 1960s, and has also stretched its demands on them beyond what is possible.

The equivalent of the army is what is now known as the Mobile Command. With a total strength of 13,000 (plus an unknown number of the 48,000 Canadian Armed Forces personnel that are not identified by service) the Mobile Command has the major responsibility of dealing with any small-scale incursion or raid into Canada by hostile forces; of maintaining the internal security of the state as required by the civil authorities; of providing the Canadian land forces commitment to the NATO forces in Europe; and of providing both in Canada itself and abroad such forces as are required by the United Nations for the peacekeeping role.

To undertake these various tasks the Mobile Command has the following units:

Canada

- two combat brigade groups (each with one armoured, one artillery, and one engineer regiments, three infantry battalions and support units)
- one Special Service Force (with one armoured, one airborne, one artillery and one engineer regiments, one infantry battalion and a support unit)

Of these the airborne regiment provides an airmobile battalion for use by the United Nations if required. In war the Special Services Forces would form the basis of the Canadian Combined Air/Sea Transportable (CAST) brigade group which is tasked with reinforcing NATO's northern flank in Norway along with a US Marine Corps amphibious force and the British/Netherlands Amphibious Force.

Europe

- one mechanized brigade group (with one armoured, one self-propelled medium artillery and one mechanized engineer regiments, two mechanized infantry battalions, a support unit and a light aviation squadron with 11 CH-136 observation helicopters)

As part of Canada's United Nations commitment the Canadian-based infantry battalions rotate through the UN force in Cyprus, while smaller specialist units are deployed with UN detachments in the various Middle East trouble spots.

To support the Mobile Command units in Canada, the 10th Tactical Air Group of the Air Command (15,300 men) is subordinated to it with six helicopter squadrons that fly a total of 31 CH-135 (Bell UH-1N), 36 CH-136 (Bell OH-58 Kiowa) and seven CH-147 (CH-47D Chinook) helicopters.

The remaining continental Air Command elements comprise two ground-attack squadrons and a training squadron equipped with 24 CF-116 (Northrop F-5A) and 25 CF-116D (Northrop F-5B) fighter-bombers, three air-defence squadrons and a training squadron which are being re-equipped with the CF-188 (McDonnell Douglas F-18 Hornet) multi-role fighters to replace CF-104 (Lockheed F-104G Starfighter) aircraft, and a training squadron equipped for the ECM role. In war the two ground-attack squadrons would revert to NATO control for use in Europe.

Both regular and militia units of the Canadian army use a modified version of the Swiss MOWAG Piranha 6×6 APC. Three models are now in service; 261 basic APCs, 189 vehicles fitted with the same turret as the British Scorpion light tank, and 26 armoured recovery vehicles.

Under the actual control of NATO's 4th ATAF HQ and based in West Germany is the 1st Canadian Air Group with three squadrons of 42 CF-104s that are being replaced by 54 CF-188s. A total of 113 CF-188A single-seat and 25 CF-188D two-seat fighters are being procured in the Air Command's largest replacement programme for a number of years.

This Canadian Leopard tank has just 'captured' the American M113 APC in the foreground during an exercise in West Germany. Canada ordered 114 Leopard 1A3s fitted with the Belgian fire control system, part-exchanging them for their old Centurion tanks with Krauss-Maffei.

12 PASS

Canada's three air-defence squadrons are currently re-equipping with the CF-118 (McDonnell Douglas F-18 Hornet), as are the CF-104 Starfighter units of the 1st Canadian Air Group based in Germany. The false cockpit canopy painted on the belly is to confuse enemy fighter pilots.

For transport support and SAR duties for all the service commands there exists the Air Transport Group of five fixed-wing transport squadrons, four mixed fixed-wing/rotary-wing transport and SAR squadrons, four helicopter base flights and an independent SAR helicopter flight. These fly a total of 88 aircraft, the most important of which are the 23 CC-130E/H (Lockheed Hercules) and 11 CC-115 (de Havilland Canada DHC-5A) transports, and 10 CH-113 (Boeing Vertol CH-46) helicopters.

All the training for these aircraft and the other commands is undertaken by the Training Group, which has three air schools and an aerobatic display team which mostly fly some 111 examples of the locally-built Canadair CT-114 light jet trainer.

For the specialist naval support role there is the Maritime Air Group which is under control of the Maritime Command (MARCOM). This operates three maritime patrol squadrons with 18 examples of the Lockheed CP-140 Aurora version of the P-3 Orion, and a maritime survey/pollution control squadron equipped with 15 elderly CP-121 (Grumman Tracker) aircraft. A reserve squadron also flies the CP-121. For duty afloat and ashore training there are three squadrons of 32 CH-124 (Sikorsky SH-3 Sea King) ASW helicopters, while for miscellaneous duties there are two utility squadrons flying a mix of helicopters, CP-121s and CT-133 (Lockheed T-33) jets. The Sea Kings are deployed aboard the destroyers and the fast replenishment ships of MARCOM.

The Maritime Command is split into two fleets based in the Atlantic and Pacific. The former, home-ported at Halifax, has three 'Oberon' class submarines, 12 active and one reserve destroyers plus two replenishment ships. The Pacific component, based at Esquimault, has the remaining eight active and two reserve destroyers and one replenishment ship. Total manpower is about 5,500, and other assets are 12 smaller patrol vessels.

A civilian coast guard of about 6,500 men with 25 icebreakers, 37 helicopters, 16 SAR vessels and three hovercraft provides valuable back-up. The oldest destroyers are due to be replaced by a new series of six ASW frigates which have been planned for a number of years. The other major naval-orientated procurement programme is the mid-life refit and updating of the 'Oberon' class submarines with new sonars, and new weapons in the form of the Sub-Harpoon underwater-launched anti-ship missile and the long-range dual-role ASW/anti-ship Mk 48 torpedo.

As far as possible Canada has tried to build most of her weapons and equipment in Canada, usually under licence and modified specifically to her needs. Exceptions to this are tanks, some towed and all self-propelled artillery, which have been procured in such relatively small numbers that they would be too expensive if locally built.

The Mobile Command uses the following equipment:

armour: Leopard C-1 MBT, M113 C & R Lynx armoured reconnissance vehicle, Cougar WFSV, Grizzly WAPC and M113 APC;
artillery: (towed) 105-mm (4.13-in) C5 pack howitzer (Italian M56), 105-mm C1 howitzer (Canadian copy of US M101)
(self-propelled) 155-mm (6.1-in) M109A1
(mortars) 81-mm (3.19-in) (developed with the UK);
anti-armour weapons: 84-mm (3.3-in) Carl Gustav and 106-mm (4.17-in) M40 recoilless rifles, 66-mm (2.6-in) LAW rocket-launcher and TOW ATGW;
air-defence weapons: 40-mm L/60 Boffin (Canadian copy of L/60 Bofors) and Blowpipe SAM; and
small arms: 9-mm Browning pistol, 5.56-mm M16A1 and 7.62-mm C1/C2 assault rifles, 7.62-mm M1919 Browning medium machine-gun and 12.7-mm Browning heavy machine-gun.

The major procurement programmes of recent years have been the purchase of 114 Leopard 1 MBTs, eight Leopard ARVs and six Leopard bridge-layer tanks from West Germany; and the licence production of 491 Cougar wheeled fire-support vehicles with 76-mm (3-in) Alvis Scorpion turrets, Grizzly wheeled APCs and Husky wheeled maintenance and recovery vehicles based on the Swiss MOWAG Piranha 6×6 armoured vehicle.

Canadian Continental Air Command includes two ground-attack squadrons which use Northrop F-5As and F-5Bs under the designations CF-116 and CF-116D. Note the inflight-refuelling probe forward of the cockpit.